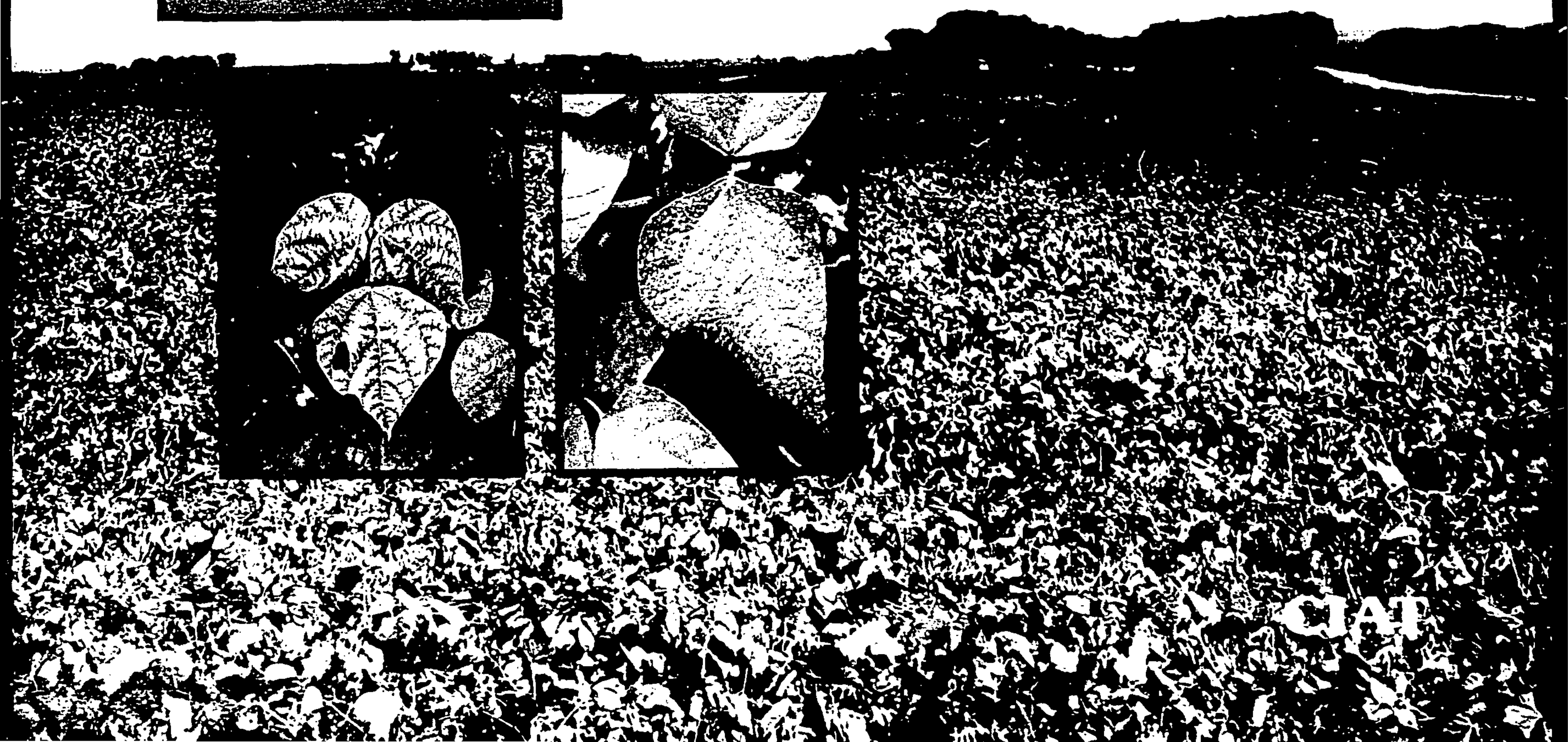
FIELD PROBLEMS OF BEANS IN LATIN AMERICA



CIAT

FRONT COVER: Four field problems of beans. **Background,** a field severely infected with bean common bacterial blight (H. F. Schwartz); **top insert,** *Heliothis virescens* feeding (A. van Schoonhoven); **lower left,** manganese toxicity (H. F. Schwartz); **lower right,** paraquat chemical damage (H. F. Schwartz).

BACK COVER: **Left,** a disease observation trial at the Obonuco Experimental Station of ICA, near Pasto, Colombia (H.F. Schwartz); **right,** clean seed production of a promising variety at the Quilamapu Experimental Station of INIA, near Chillan, Chile (H. F. Schwartz).

CIAT is a nonprofit organization devoted to the agricultural and economic development of the lowland tropics. The Government of Colombia provides support as host country for CIAT and furnishes a 522-hectare farm near Cali for CIAT's headquarters. Collaborative work with the Instituto Colombiano Agropecuario (ICA) is carried out on several of its experimental stations and similar work is done with national agricultural agencies in other Latin American countries. CIAT is financed by a number of donors represented in the Consultative Group for International Agricultural Research. During this year these donors are the United States Agency for International Development (USAID), the Rockefeller Foundation, the Ford Foundation, the W. K. Kellogg Foundation, the Canadian International Development Agency (CIDA), the International Bank for Reconstruction and Development (IBRD) through the International Development Association (IDA), the Inter-American Development Bank (IDB) and the governments of Australia, Belgium, the Federal Republic of Germany, Japan, the Netherlands, Norway, Switzerland and the United Kingdom. In addition, special project funds are supplied by various of the aforementioned entities plus the International Development Research Centre (IDRC) of Canada and the United Nations Development Programme (UNDP). Information and conclusions reported herein do not necessarily reflect the position of any of the aforementioned agencies, foundations or governments.

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FIELD PROBLEMS OF BEANS IN LATIN AMERICA

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Contents

General Introduction

Beans comprise an important protein component in the diets of most Latin American people. Despite their importance, national yields average only 600 kg/ha, but beans possess the potential to yield over 4,000 kg/ha. This great difference between actual and potential yields is primarily caused by plant disease/insect pest complexes and soil nutritional problems encountered in farmers' fields.

This booklet is intended to aid scientists, technicians, extension agents and farmers in the identification of production problems and development of control measures. As an aid in fully describing problems encountered in the field, some names commonly used in Latin America are listed in blue on the right-hand margin. Photographs of fungal structures and insects in this book are approximately life-size, except where the estimated magnification is noted under the photograph.

A. Plant Diseases

Introduction

Beans grown in the tropics are affected by many plant diseases caused by fungi, bacteria, viruses and nematodes. A larger number of plant pathogens exist and infect beans grown in the tropics than in temperate zones of the world. In the tropics beans are grown almost continuously and under diverse environmental conditions favorable for infection by and survival of pathogens. Environmental conditions range from high temperature and moisture present in tropical lowland areas to low temperature and high moisture present in sub-tropical highland areas. Some plant pathogens are restricted to specific regions; for example, web blight and bean golden mosaic virus are prevalent in various lowland regions, while anthracnose is prevalent in various highland regions. Other plant pathogens, like bean common mosaic virus and rust, are present throughout all growing regions.

I. Virus Diseases

NOTES

1. Aphid Transmitted Viruses

1.1 Bean Common Mosaic

Mosaico Común
Mosaico Comum

Bean common mosaic virus (BCMV) is a serious problem of beans throughout the world. Symptom expression may be affected by strain of the virus, degree of resistance of the bean variety or age of the plant, and different environmental conditions such as temperature. Leaf symptoms include light- and dark-green mottled or mosaic patterns on leaves, which often have a cupped appearance as the leaf edges curl downwards. Infected leaves are often smaller than normal, and may have small blisters on the leaf surface (Fig. 1). Plants are often stunted, and pods and blossoms may be deformed. BCMV can be transmitted mechanically, by seed (Fig. 2) or by aphids (Fig. 3).

High temperatures (greater than 26°C) may cause the production of local necrotic lesions on leaves (Fig. 4) or plant systemic necrosis when resistant plants are infected by strains of BCMV. This reaction is actually a hypersensitive response of the resistant plant to infection by the virus. Systemic necrosis begins with a slight wilting of young leaflets at any stage of plant growth; leaves turn brown or nearly black and then wilt (Fig. 5), followed by complete plant wilting and death. The plant vascular system also becomes necrotic (Fig. 6). The virus causes a normal systemic mosaic reaction at high temperatures in susceptible plants.

BCMV is controlled by planting resistant varieties. Disease incidence can be reduced by planting virus-free seed, and controlling the insect vector population (see Section 11.1).

Fig. 1

Fig. 2

Fig. 3 (5X)

Fig. 4

Fig. 5

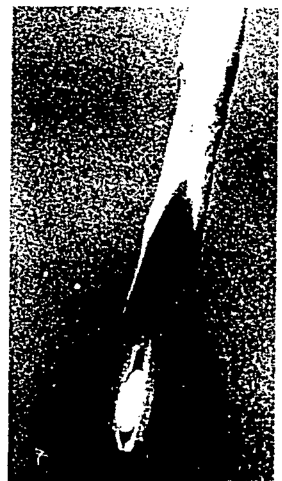

Fig. 6

1.2 Bean Yellow Mosaic

Mosaico Amarillo
Moteado Amarillo
Mosaico Amarelo

NOTES

Bean yellow mosaic virus (BYMV) has a wide range of hosts including beans, soybeans, clover and gladiolus. Symptom expression may be affected by pathogenic strains of the virus and differences in the resistance of plant varieties. Leaf symptoms on beans consist of yellow and green, mottled or mosaic patterns (Fig. 7), which are more severe in their expression than similar symptoms of bean common mosaic virus (BCMV). Leaves tend to become brittle, concave and glossy. Infected pods and leaves may be malformed and distorted. The plant may be severely stunted, much more so than stunting caused by BCMV. Specific virus strains may cause purpling of the leaf bases of lower leaves which may result in death of the plant. BYMV is not transmitted by seed, but is easily transmitted mechanically and by aphids.

Control measures consist of planting resistant varieties and controlling the insect vector population (see Section 11.1).

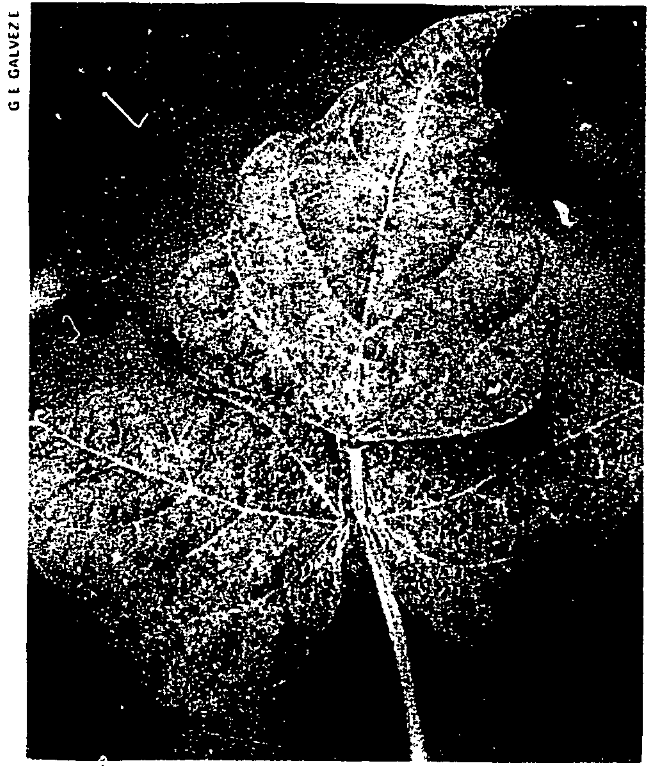

Fig. 7

2. Whitefly Transmitted Viruses

NOTES

2.1 Bean Golden Mosaic — Mosaico Dorado
Bean Golden Yellow Mosaic — Mosaico Dourado

Bean golden mosaic virus (BGMV) is a serious problem in many tropical areas of the world where beans and lima beans are grown. Leaf symptoms consist of a yellow and green mosaic pattern which may cause the infected leaf to curl downwards (Fig. 8). Recently-emerged trifoliate leaves show bright yellow, general mosaic patterns; these may contrast sharply with the older leaves which exhibit less distinct mosaic symptoms (Fig. 9). Infected plants are easily observed in the field by their general yellow appearance. Some varieties may be stunted and have malformed pods (Fig. 10). High populations of the whitefly insect vector (*Bemisia tabaci*) are necessary to cause BGMV epidemics (Fig. 11). BGMV can be transmitted mechanically, but is not seedborne. Weeds may also serve as reservoirs of inoculum.

Control measures consist of planting resistant or tolerant varieties and control of the insect vector population (see Section 11.4).

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Fig. 9

Fig. 8

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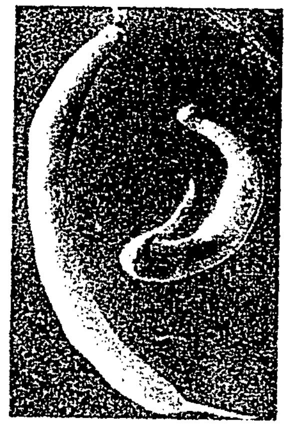


Fig. 10

J BIRD

Fig. 11 (0.5 X)

2.2 Bean Chlorotic Mottle

Bean Crumpling
Euphorbia Mosaic
Bean Dwarf Mosaic
Abutilon Mosaic
Rhynchosia Mosaic

Moteado Clorotico
Mosaico de las Euforbiáceas
Enrollamiento de la Hoja
Clorosis Infecciosa
Mosaico de la Rhynchosia
Enanismo del Fríjol
Anão Amarelo
Clorose Infecciosa das Malváceas
Encarquilhamento da Fõlha
Mosaico Anão

NOTES

Bean chlorotic mottle virus (BCLMV) does not usually cause serious losses to beans, but may frequently be observed. Because of a lack of characterization, we have included under this virus name several virus diseases with similar symptoms described by different workers. Leaf symptoms include chlorotic mottled patches with some associated leaf curling and deformation in certain varieties (Fig. 12). If infection occurs during the early seedling stage, a susceptible plant may be severely stunted and produce a witches'-broom (Fig. 13). Several weeds such as *Sida* sp., *Euphorbia* sp. and other common tropical weeds serve as reservoirs of inoculum. The virus is transmitted by the whitefly (*Bemisia tabaci*).

Control measures consist of planting resistant varieties and controlling the insect vector population (see Section 11.4).

Fig. 12

Fig. 13

3. Beetle Transmitted Viruses

NOTES

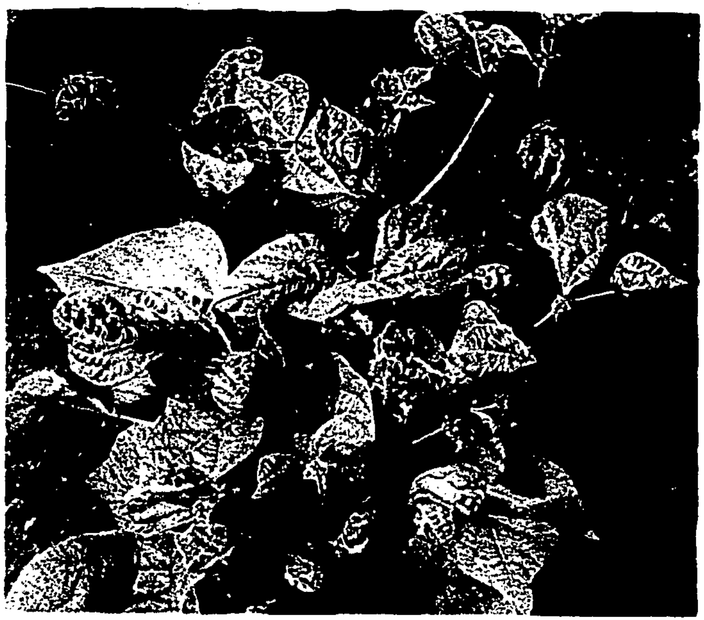
3.1 Bean Rugose Mosaic

Mosaico Rugoso
Ampollado
Arrugamiento
Encarrugamiento
Mosaico em Desenhos

Bean rugose mosaic virus (BRMV) produces symptoms which may resemble those caused by BCMV. Symptoms can vary among pathogenic strains of the virus and differences in the resistance of plant varieties. Leaf symptoms include a light- and dark-green mosaic pattern, often accompanied by severe leaf blistering, curling and malformation with a thickened or leathery appearance (Fig. 14). Plants are often quite stunted, especially if infection occurs during the seedling stage of growth. Pods may be malformed and exhibit a mosaic pattern. BRMV is transmitted mechanically, and by species of *Cerotoma* and *Diabrotica*.

Control measures consist of planting resistant varieties and virus-free seed, and controlling the insect vector population (see Section 10.2).

Fig. 14



G E GALVEZ E

3.2 Bean Southern Mosaic

Mosaico Sureño

NOTES

Bean southern mosaic virus (BSMV) has been reported to occur in many countries of Latin America. The virus may produce circular, brownish-red local lesions 1-3 mm in diameter, or systemic mottle and vein banding symptoms, depending upon the variety inoculated. The mottle symptoms commonly resemble those produced by BCMV and BYMV, but they are less intense than those produced by the latter two viruses. Leaves may have blisters and be malformed. Pod symptoms may consist of dark-green, water-soaked blotches which are irregular in shape. BSMV is seed-borne and commonly detected by serological techniques (Fig. 15).

Control measures consist of planting virus-free seed and resistant varieties.

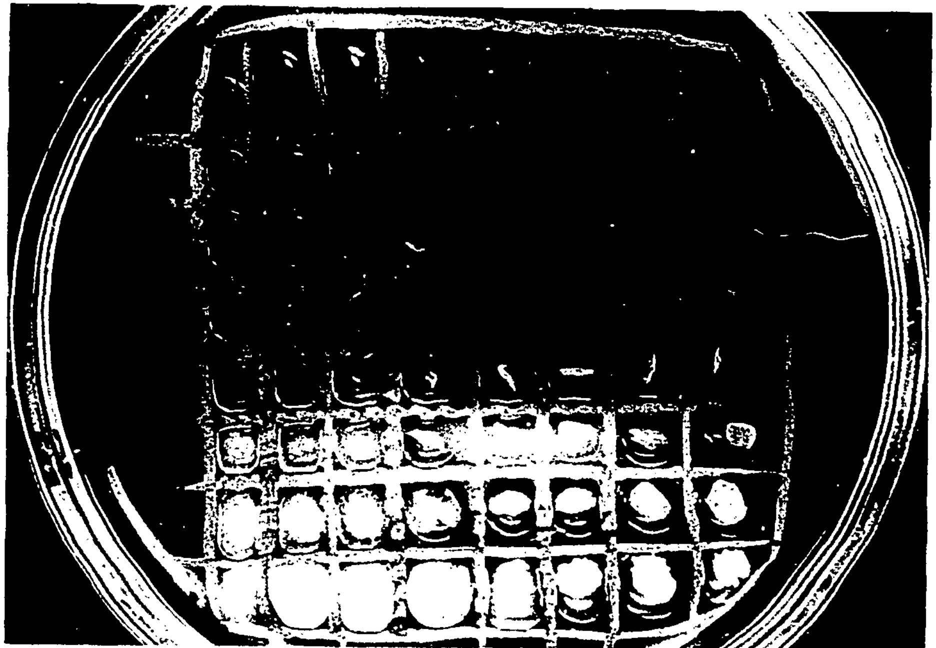


Fig. 15

II. Fungal Diseases

NOTES

4. Foliage and Pod Infecting Fungi

4.1 Alternaria Leaf Spot — Mancha Parda

Alternaria alternata (Fr.)Keissler — Mancha Foliar por Alternaria

Alternaria tenuis Nees

Alternaria leaf spot can be a problem in locations with high humidity and relatively cool temperatures (16-24°C). Leaf symptoms appear as small reddish-brown, irregular zonate lesions surrounded by a darker brown border. These lesions gradually enlarge and develop as concentric rings, which often become brittle and fall out leaving a shot-hole appearance (Fig. 16). Lesions may coalesce and cover large areas of the leaf resulting in partial or premature defoliation. *Alternaria* sp. can cause death of the central growing point of the plant or reduce plant vigor. The fungus can also blemish leaves (Fig. 17) and pods (Fig. 18) by producing a brown discoloration on the surface and damage to developing seeds.

Control measures include crop rotation, application of chemicals (benomyl or thiophanate) and development of resistant varieties.

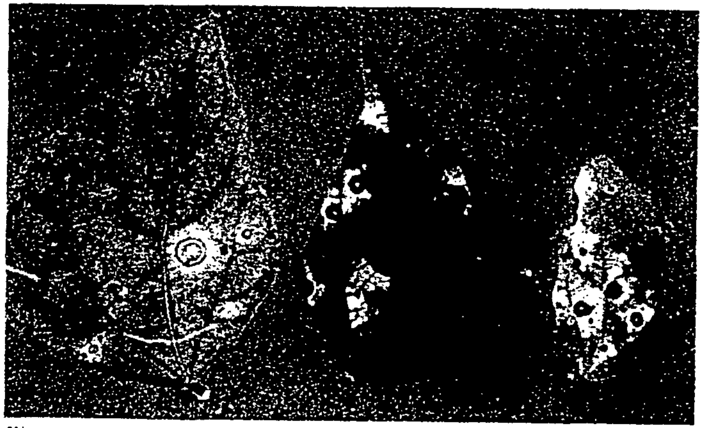


Fig. 16

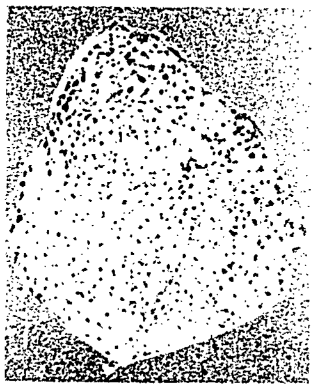


Fig. 17

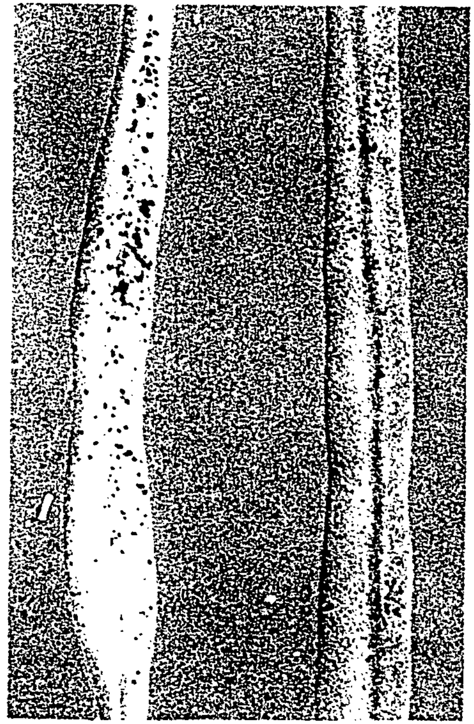


Fig. 18

4.2 Angular Leaf Spot — Mancha Angular

NOTES

Isariopsis griseola Sacc.

Angular leaf spot of beans (Fig. 19), is present in many regions of the world. Infection and development of this fungus are favored by moderate temperatures (18-25°C) and periods of high humidity or moisture. Leaf signs and symptoms generally appear first on the lower leaf surface as gray spots, which later turn brown and become covered by small columns of hyphae (synnemata) which bear gray-to black-colored conidia (Fig. 20). The lesions are angular because of delimitation by the veins and veinlets. Brown angular lesions are also apparent on the upper leaf surface, but usually do not bear synnemata. Pod and stem lesions are reddish-brown and often surrounded by a dark-colored border (Fig. 21). The pathogen can become seedborne, and transmission also occurs from windblown spores.

Control measures include crop rotation, planting seed free of the fungus and resistant varieties, and application of chemicals (benomyl or thiophanate).

H. F. SCHWARTZ

Fig. 19

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Fig. 20

G. ALVAREZ

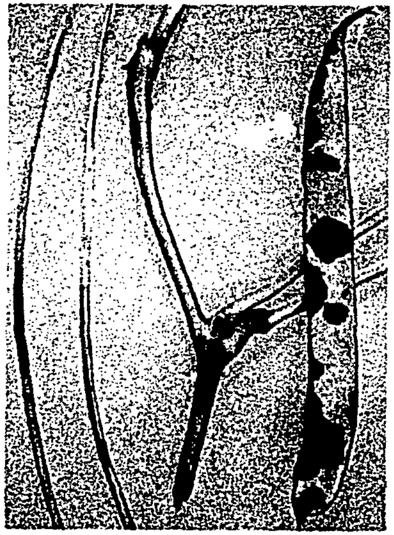

Fig. 21

4.3 Anthracnose

Colletotrichum lindemuthianum
(Sacc. and Magn.) Scribner

Antracnosis
Antracnose

NOTES

Bean anthracnose (Fig. 22), is prevalent throughout most regions of the world, especially at elevations above 1000 m. Infection and development by this pathogen are favored by cool temperatures (14-18°C) and high humidity or free moisture. Spores are disseminated by wind and rain or movement through fields by man, animals and insects. Leaf symptoms (Fig. 23), initially appear on lower leaf surfaces and consist of dark brick-red to black lesions along the leaf veins and veinlets. These lesions may also appear on the leaf petiole, branch, cotyledon, stem or pod. Pod infection generally appears as pink or rust-colored to black spots which develop into sunken cankers containing pinkish masses of spores (Fig. 24). The fungus can become seedborne and cause severe yield losses. Anthracnose symptoms may be confused with Ascochyta symptoms, however, their differences are apparent (compare with Section 4.4).

Control measures include crop rotation, planting seed of resistant varieties and seed free of the fungus, and application of chemicals (fentin acetate, captafol or benomyl). Resistance is affected by the existence of different pathogenic races.

Fig. 22

Fig. 23

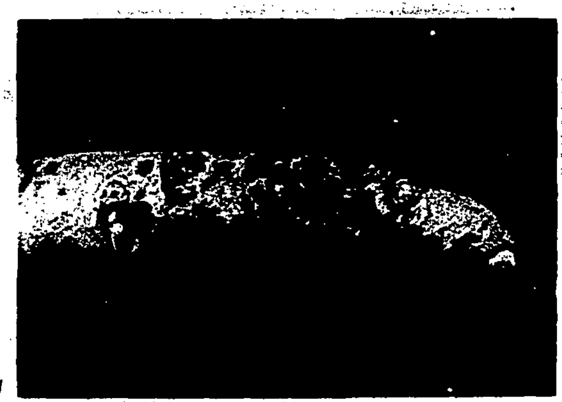

Fig. 24

4.4 Ascochyta Leaf Spot

Mancha de Ascochyta

NOTES

***Ascochyta boltshauseri* Sacc.**

***Ascochyta phaseolorum* Sacc.**

Ascochyta leaf spot is primarily a problem at highland elevations greater than 1500 m, and is favored by cool temperatures and high humidity or moisture. Leaf signs and symptoms consist of dark-gray to black zonate lesions (Fig. 25), which may contain small, black pycnidia. Lesions may also appear on the peduncle, petiole (Fig. 26) and pod (Fig. 27), and cause stem girdle and plant death. Premature leaf drop may occur during severe epidemics. The fungus can be seedborne.

Control measures include crop rotation, planting of resistant varieties or seed free of the fungus, and application of chemicals (zineb or benomyl).

Fig. 26

Fig. 27

Fig. 25

4.5 Chaetoseptoria Leaf Spot — Mancha Redonda

NOTES

Chaetoseptoria wellmanii Stevenson

Chaetoseptoria leaf spot can be a problem in regions with moderately cool temperatures and moist environments. In México infection usually occurs on the primary leaves soon after plant emergence. Leaf signs and symptoms consist of circular lesions with light-tan to cream centers surrounded by a reddish-brown border (Fig. 28). Small gray pycnidia may form in the lesion . Severe leaf defoliation and yield loss may occur. The fungus is suspected to be seedborne.

Control measures include crop rotation, planting seed free of the fungus, application of chemicals (benomyl) and development of resistant or tolerant varieties.

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Fig. 28

4.6 Floury Leaf Spot

Ramularia phaseoli (Drummond) Deighton

Mancha Harinosa
Mancha Farinhosa
Môfo Branco da Fôlha

NOTES

Floury leaf spot can occur in regions with moderate temperatures and moisture. Leaf signs and symptoms consist of white angular lesions which may coalesce and appear irregular on the lower surface of leaves (Fig. 29). The fungus characteristically produces a white floury-like growth of mycelium and spores. There may be a light-green or yellow discoloration present on the upper leaf surface, with no evidence of mycelium or spores. Infection generally occurs first on the older leaves and progresses onto new foliage. Severe infection may cause premature defoliation.

Control measures include crop rotation, application of chemicals (thiophanate or benomyl) and development of resistant or tolerant varieties.

Fig. 29

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4.7 Gray Spot — Mancha Gris

NOTES

Cercospora vanderysti P. Henn

Gray spot (Fig. 30) is prevalent at elevations greater than 1500 m where cool temperature and high moisture conditions persist. Leaf signs and symptoms consist of pale-green to chlorotic angular lesions (2-5 mm in diameter) on the upper leaf surface (Fig. 31). A grayish-white powdery growth of mycelium and spores may be present in these lesions on the upper leaf surface. A grayish mat of mycelium and spores is produced on the lower leaf surface (Fig. 32), and is very characteristic of the fungus. Severe infections may cause premature defoliation.

Control measures include crop rotation, planting resistant varieties and application of chemicals (copper hydroxide or benomyl).

Fig. 32

4.8 Gray Mold

Botrytis cinerea Pers. *ex* Fries

Botryotinia fuckeliana (de Bary) Whetz.

Moho Gris

Podredumbre Gris

Bolor Cinzento

NOTES

Botrytis cinerea is the conidial or sporulating stage of *Botryotinia fuckeliana*, and can be a problem during periods of low temperature and high moisture. Infection usually occurs at wounds on plant parts such as leaves, stems or pods, or senescent blossoms colonized by the fungus (Fig. 33). Symptoms appear as a watersoaked, gray-greenish area on the affected tissue, which subsequently wilts and dies. Seedlings may also become wilted and die, but damage is usually limited to a watery. soft rot of pods.Black stromata and sclerotia (up to 4 mm in diameter) may form in infected tissue and resemble those formed by *Sclerotinia*. Apothecia and or mycelium may be produced by a germinating sclerotium of *B. fuckeliana* (Fig. 34), and account for variability in virulence.

Control measures include reducing the plant density, application of chemicals (benomyl) and development of resistant varieties.

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Fig. 33

G S ABAWI

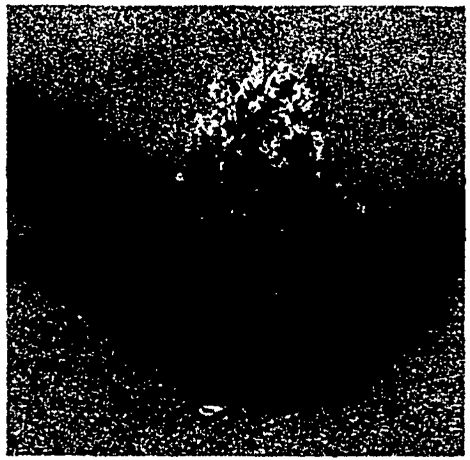

Fig. 34 (3 X)

4.9 Powdery Mildew

NOTES

Oídium

Mildeo Polvoso

Mildiú Velloso

Míldio Pulverulento ou Cinza

Erysiphe polygoni DC *ex* Merat

Oidio

Powdery mildew (Fig. 35) is distributed worldwide and its growth is favored by low humidity and moderate temperatures. However, the fungus can be prevalent over a wide range of environmental conditions. Severe damage may occur if young plants are infected, however, infection is usually noticeable only on older plants and seldom reduces yields. Leaf signs and symptoms include an initially darkened area on the leaf which subsequently becomes covered by white, powdery spots, generally only on the upper surface (Fig. 36). These superficial spots may coalesce and cover the entire leaf with a white powder of mycelium and spores. Severe infection may cause premature defoliation. Infection may occur on the stem and pods, causing the latter to be malformed and have a brown to purple discoloration (Fig. 37). Spores may be present on the outside of the seeds, but the primary dissemination of spores occurs by wind currents.

Control measures include planting fungus-free seed or seed of resistant varieties and chemical applications (dinocap, lime sulfur or sulfur). Resistance is affected by the existence of different pathogenic races.

H F SCHWARTZ

Fig. 35

S K MOHAN

Fig. 36

H F SCHWARTZ

Fig. 37

4.10 Rust

Roya

Uromyces phaseoli (Reben) Wint.

Chahuixtle

Uromyces appendiculatus (Pers.) Unger

Ferrugem

NOTES

Bean rust is prevalent throughout most regions of the world. Infection by this obligate parasite is favored by moderate temperatures (17-27°C) and high relative humidity or free moisture. Rust spores are primarily transmitted by local and prevailing wind currents. Severe yield losses can result if infection occurs early in the season before flowering. Leaf signs and symptoms may consist of chlorotic or white spots which develop into reddish-brown pustules or uredia on the lower and upper leaf surfaces (Fig. 38). A pustule contains thousands of brown urediospores during the growing season or dark-brown teliospores near the end of the season, especially in temperate regions of the world. The pustules may be surrounded by a chlorotic or necrotic border (Fig. 39), depending upon the pathogenic race, variety and environmental conditions. Severe infection may cause premature defoliation. Pod infection may also occur (Fig. 40).

Control measures include destruction of old plant debris, crop rotation, application of chemicals (oxycarboxin, benomyl or maneb) and planting resistant or tolerant varieties. Resistance is affected by the existence of different pathogenic races. Figure 41 illustrates the effect of rust infection upon a resistant and a susceptible variety.

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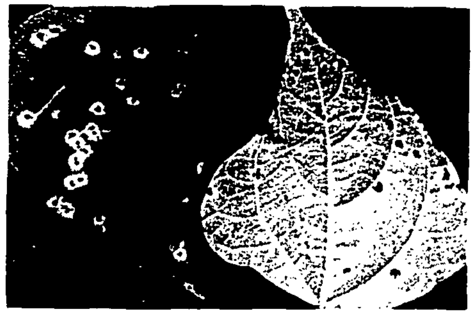
Fig. 38



H F SCHWARTZ

Fig. 39

H F SCHWARTZ

Fig. 40

D R LAING

Fig. 41

4.11 Smut — Carbón

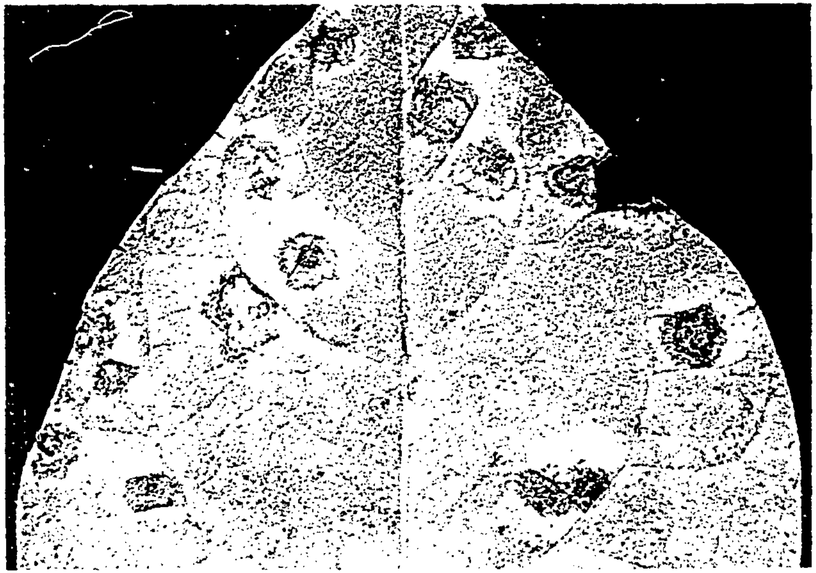
NOTES

Entyloma petuniae Speg.

Leaf blister smut occurs in many regions of Central America and the islands of the Caribbean. Leaf signs and symptoms on the upper leaf surface consist of grayish-black blisters or lesions (Fig. 42) which contain subepidermal masses of black chlamydospores. Lesions are often delimited by the leaf veins or veinlets. Infection usually occurs first on the primary or first and second trifoliate leaves.

Control measures include destruction of old plant debris, crop rotation, application of chemicals (carboxin) and development of resistant varieties.

Fig. 42



NOTES

4.12 Web Blight

Mustia Hilachosa

Rhizoctonia del Follaje

Chasparria

Rhizoctonia microsclerotia Matz.

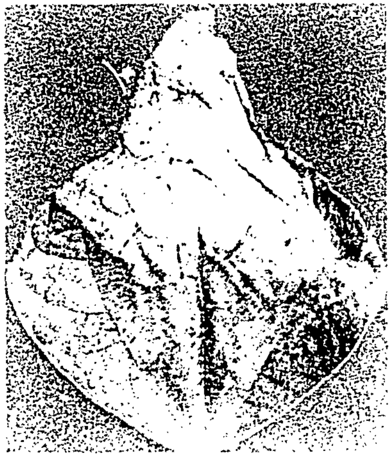
Murcha da Teia Micélica

Thanatephorus cucumeris (Frank) Donk

Podridão das Vagens

Web blight can cause severe yield losses when beans are grown in the lowland tropics where high temperature and moisture conditions persist. Leaf signs and symptoms begin as small watersoaked spots wich appear to be scalded light green to gray, and often surrounded by a dark border (Fig. 43). The fungus produces tan-colored hyphae which grow from these spots to uninfected foliage, eventually covering the entire plant with a web of hyphae if environmental conditions are favorable (Fig. 44). Pods can also be infected by the fungus. The fungus produces small brown sclerotia (0.2-0.5 mm in diameter) which can survive in the soil. The fungus can become seedborne.

Control measures include destruction of plant debris, crop rotation, planting seed free of the fungus, application of chemicals (benomyl), and development of varieties with open plant canopies and/or tolerance.



4.13 White Mold

Moho Blanco del Tallo
Sclerotinia
Esclerotiniosis
Podredumbre Algodonosa
Môfo Branco
Murcha de Sclerotinia

Sclerotinia sclerotiorum (Lib.) de Bary
Whetzelinia sclerotiorum (de Bary) Korf and Dumont

White mold is distributed worldwide, and has a very wide range of hosts which includes most vegetables and many weed species. This fungus is favored by moderate to cool temperatures, high humidity or moisture and senescent plant tissue (Fig. 45). Symptoms and signs of infection initially appear as a water-soaked lesion, followed by a white moldy growth on the affected plant organ such as a leaf or pod (Fig. 46). This infected tissue later becomes dry, light-colored and has a chalky or bleached appearance. Black sclerotia (1-10 mm in diameter or larger) form in and on infected tissue within a few days after infection. The entire plant and its parts may become infected, but generally infection occurs on above-ground plant parts. The fungus can be seedborne, however, it is primarily disseminated as sclerotia or spores released by a fruiting structure called an apothecium (Fig. 47), produced from a sclerotium buried in the soil.

Control measures include crop rotation, application of chemicals (PCNB, thiophanate or benomyl), reducing plant densities, and planting varieties which possess an upright plant architecture with an open plant canopy, and/or resistance or tolerance.

Fig. [illegible]

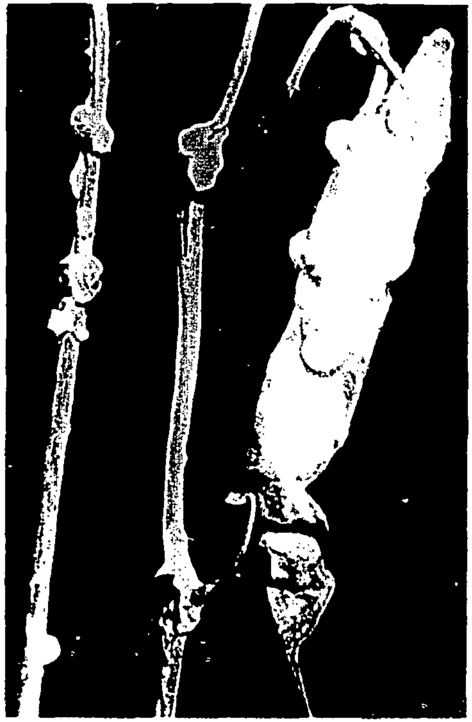


Fig. [illegible]

Fig. [illegible]

5. Root and Stem Infecting Fungi

NOTES

5.1 Ashy Stem Blight

Pudrición Gris de la Raíz

Podredumbre Carbonosa

Macrophomina phaseoli (Maubl.) Ashby — Podridão Cinzenta do Caule

Ashy stem blight can occur in regions with warm temperatures and moderate to high moisture conditions. The fungus is a pathogen of beans, soybeans, maize and other crops. Symptoms usually appear after soilborne mycelia or sclerotia germinate and infect seedling stems near the soil surface or at the base of developing cotyledons. The fungus produces black, sunken cankers which have a sharp margin and often contain concentric rings. The plant growing tip may be killed or the stem may break. Older seedling and plant infections may cause stunting, leaf chlorosis, premature defoliation, hypocotyl and root degradation, and plant death. Infection is often more pronounced on one side of the plant (Fig. 48). Older lesions turn gray and often contain small black pycnidia (Fig. 49) or sclerotia (Fig. 50). The fungus can be seedborne.

Control measures include planting seed free of the fungus, crop rotation, deep plowing, application of chemicals (benomyl) and development of resistant varieties.

H. F. SCHWARTZ

Fig. 48

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Fig. 50 (2 X)

H. F. SCHWARTZ

Fig. 49 (2 X)

5.2 Fusarium Root Rot — Pudrición Seca

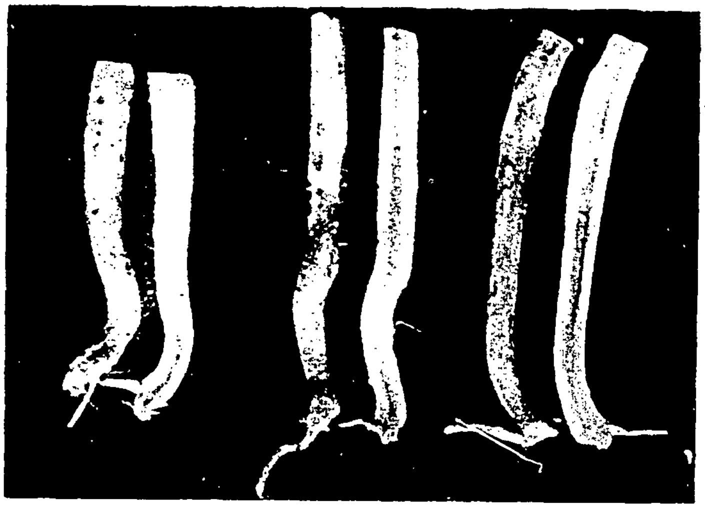
NOTES

Fusarium solani (Mart.) Appel and Wollenw.
f. sp. *phaseoli* Snyder and Hansen — Podridão Radicular Sêca

Fusarium root rot produces symptoms which include reddish streaks or lesions on the primary root one to two weeks after germination. This discoloration increases in intensity and extent, and may cover the entire root system. The red color later turns brown and longitudinal fissures or cracks may appear on the exterior of the taproot and extend to the soil surface (Fig. 51). The primary and lateral roots are commonly killed by the fungus and persist as dried remnants, however, secondary roots may develop above lesions on the primary root. The main root and lower plant stem may become infected and eventually turn pithy. Small bluish-green masses of conidia may be observed on old lesions. Plants usually are not killed by the fungus, however, yields can be reduced.

Control measures include crop rotation, wide plant spacing, planting in uncompacted and warm soils, application of chemicals (thiram, Ceresan or benomyl) and planting of resistant or tolerant varieties.

Fig. 51



5.3 Fusarium Yellows — Marchitamiento por Fusarium — NOTES

Fusarium oxysporum Schlecht. — Murcha de Fusarium
f. sp. *phaseoli* Kendrick and Snyder

Fusarium oxysporum produces symptoms which are easily confused with those caused by *F. solani* infection. However, *F. oxysporum* infects through root and hypocotyl wounds and causes a reddish discoloration of the vascular system in the roots (Fig. 52), stem, petioles and peduncles. It causes a yellowing of lower leaves which progresses into leaves located higher on the plant (Fig. 53). The leaves become progressively yellow and often senesce prematurely. Stunted plants occur if seedlings are infected. The fungus can be seedborne from spores located on the seed surface.

Control measures include crop rotation, planting resistant or tolerant varieties or seed free of the fungus, and application of chemicals (ethylmercury chloride or hydroxymercurichlorophenol).

H. F. SCHWARTZ

Fig. 52

H. F. SCHWARTZ

Fig. 53

5.4 Pythium Root Rot

Marchitamiento por Pythium

Murcha de Pythium

NOTES

Pythium aphanidermatum (Edson) Fritz.

Pythium debaryanum Hesse.

Pythium myriotylum Drechs.

Pythium ultimum Trow.

Phythium butleri Gubr.

Pythium root rot is caused by a complex of *Pythium* spp. and seldom causes serious yield losses. The fungus can cause root rot, damping off, and stem and branch rot. Initial symptoms appear as elongated water-soaked areas on the lower hypocotyl or roots of seedlings. These lesions become tan to light-brown in color and may be slightly sunken (Fig. 54). Plant wilt and death may occur in seedlings (Fig. 55) and even in mature plants when environmental conditions such as high temperatures and moisture persist, and allow the fungus to progress upwards onto other plant parts. The fungus can become seedborne.

Control measures include crop rotation, wide plant spacing, adequate soil aeration, planting resistant or tolerant varieties or seed free of the fungus, and application of chemicals (ethylmercury chloride or Busan-72A).

Fig. 54

Fig. 55

5.5 Rhizoctonia Root Rot

Chancro
Podredumbre del Tallo
Podridão Radicular
Tombamento

Rhizoctonia solani Kühn

NOTES

Rhizoctonia root rot produces symptoms which include reddish-brown sunken cankers of varying size on the root and hypocotyl (Fig. 56), and may cause damping-off of young seedlings. The cankers are usually delimited by a well-defined border and become rough, dry and pithy as they age. Infection often proceeds into the plant pith and causes a brick-red discoloration (Fig. 57). The fungus can be seedborne.

Control measures include crop rotation, shallow planting depth, wide plant spacing, incorporating organic soil amendments, planting resistant or tolerant varieties or seed free of the fungus, and application of chemicals (PCNB or chloroneb).

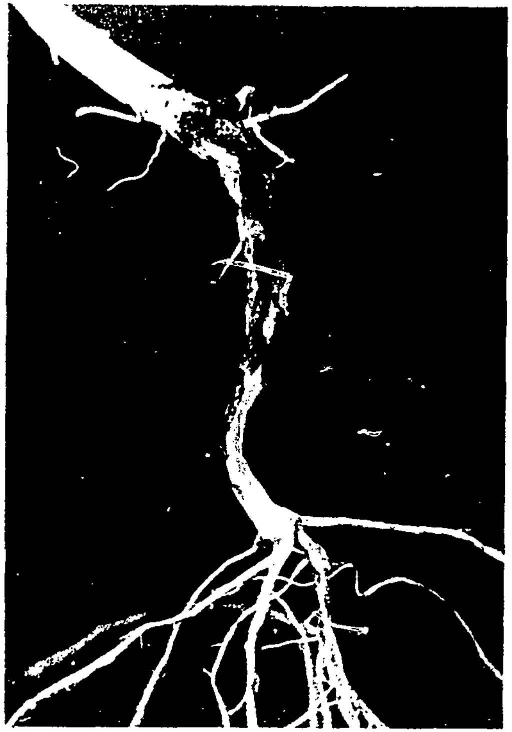


Fig. 56.

Fig. 57

5.6 Southern Blight

Añublo Sureño

Marchitamiento de Sclerotium

Maya Blanca

Pudrición Húmeda

Mal del Esclerocio

Tizón del Sud

Murcha de Sclerotium

Sclerotium rolfsii (Curzi) West.

Podridão do Colo

NOTES

Sclerotium rolfsii has a wide host range and produces symptoms which include brown, water-soaked lesions on the stem or hypocotyl just beneath the soil surface (Fig. 58). There may be a slight yellowing of the lower leaves and premature defoliation. Infection proceeds into the taproot and destroys the cortex, eventually causing plant wilt and death if environmental conditions are favorable. Signs of infection include the presence of white mycelium which adheres as a collar around the roots or hypocotyl or to soil particles (Fig. 59). The fungus also produces smooth spherical white sclerotia (1-2 mm in diameter) which become brown as they mature.

Control measures consist of crop rotation, planting of resistant or tolerant varieties, and application of chemicals (dicloran).

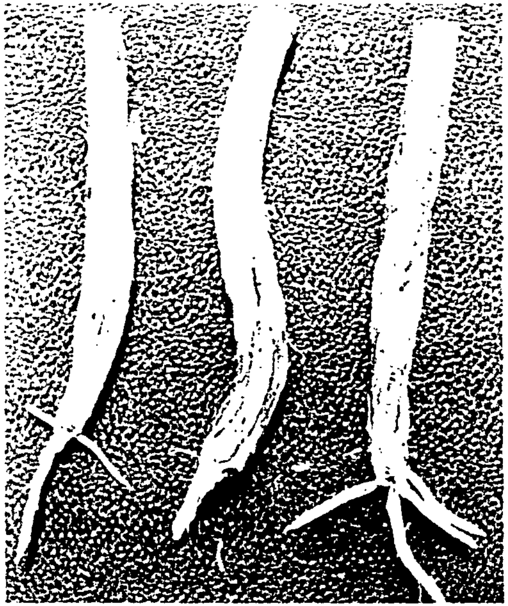


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Fig. 59

III. Bacterial Diseases

NOTES

6.1 Common and Fuscous Blights — Añublo Bacterial Común

Xanthomonas phaseoli (E.F. Sm.) Dows. — Tizón Común

Xanthomonas phaseoli var. *fuscans* (Burk.) Starr and Burkh. — Crestamento Bacteriano

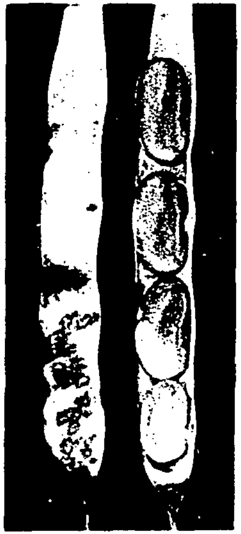
These bacteria are distributed worldwide and cause severe yield losses, especially in regions with moderate to high temperatures and moisture. Initial infection by common and fuscous blight bacteria appears as water-soaked spots on the underside of leaves or leaflets (Fig. 60). These spots subsequently enlarge irregularly and adjacent lesions may coalesce (Fig. 61). Infected regions appear flaccid, and are encircled initially by a narrow zone of lemon-yellow tissue, which may later turn brown and necrotic. Yellow droplets of bacterial ooze or exudate may be visible on and around lesions. Stems and pods may also be infected; pod infection provides the opportunity for seed discoloration and/or subsequent seed transmission of the bacteria (Fig. 62).

Control measures include crop rotation, planting bacteria-free seed, and tolerant varieties, and application of chemicals (copper hydroxide or streptomycin sulfate).

Fig. 60

Fig. 61

Fig. 62



6.2 Halo Blight

Añublo de Halo

Hielo Amarillo

Tizón de Halo

Crestamento Bacteriano Aureolado

Crestamento Bacteriano de Halo

Mancha Aureolada

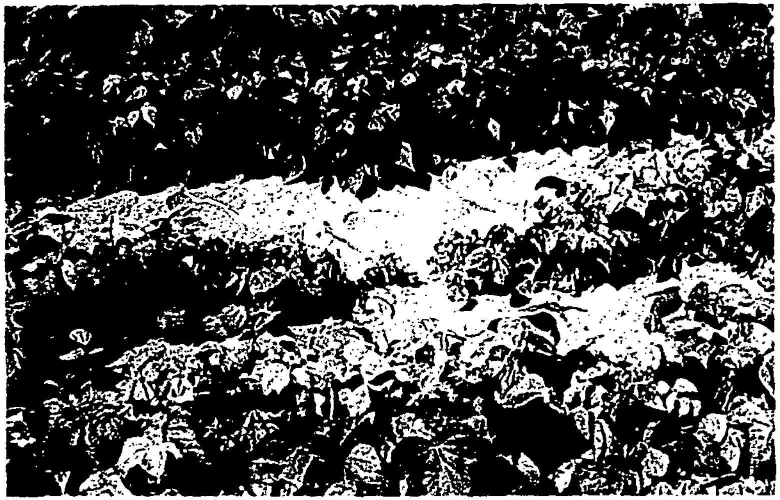
Pseudomonas phaseolicola (Burk.) Dows.

Mancha de Halo

NOTES

These bacteria are distributed worldwide and can be a serious problem (Fig. 63) in regions with cool to moderate temperatures (less than 28°C). Initial symptoms appear three to five days after infection as small, water-soaked spots generally on the lower leaf surface. A halo of greenish-yellow tissue later appears around these water-soaked areas (Fig. 64). Systemic plant chlorosis with leaf yellowing and malformation may develop without the appearance of much external infection. A light cream or silver-colored bacterial exudate may be observed on and around lesions. Stems and pods may also become infected and cause subsequent seed transmission of the bacteria.

Control measures include crop rotation, planting bacteria-free seed and resistant or tolerant varieties, and application of chemicals (copper hydroxide or streptomycin sulfate). Resistance is affected by the existence of different pathogenic strains.



D J HAGEDORN

Fig. 63

H L BISSONNETTE

Fig. 64

IV. Nematodes

NOTES

7.1 Root Knot Nematode

Meloidogyne incognita (Kofoid and White) Chitwood
Meloidogyne javanica (Treub) Chitwood

Nemátodos de los Nódulos Radicales
Galhas das Raízes

7.2 Root Lesion Nematode

Pratylenchus scribneri Steiner

Nemátodos de las Lesiones Radicales
Lesiones por Nemátodos

Various nematodes are reported to infest beans. In addition to the three listed above which will be described here, *Trichodorus* sp. (Stubby Root Nematode), *Belonolaimus* sp. (Sting Nematode), *Heterodera* sp. and *Ditylenchus* sp. have been identified on beans.

Symptoms of root knot nematode infection include plants which are stunted, yellowish and wilt during the warmest part of the day. Examination of the root system of an infected plant reveals numerous enlargements or galls (1-15 mm in diameter or larger) in which the nematodes are located (Fig. 65, left side). These galls interfere with the plant's ability to obtain moisture and nutrients from the soil and can greatly reduce yields. Figure 66 (right side) shows feeding damage by the root lesion nematode.

Control measures for the root knot and other nematodes include crop rotation, application of chemicals (carbofuran, fenamiphos or ethoprop), and development of varieties with resistance or tolerance.

J E WYATT

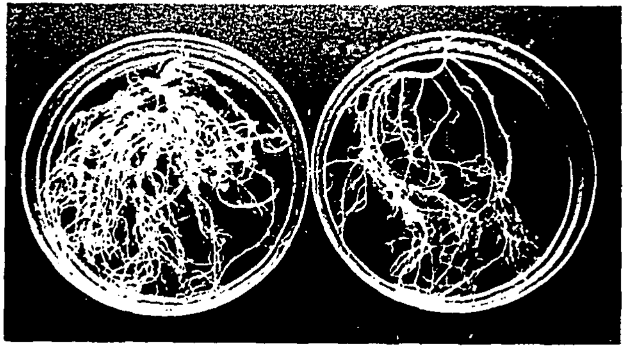


Fig. 65

G S ABAWI

Fig. 66

V. Seed Pathology

NOTES

8.1 Clean Seed Production — Producción de Semilla Limpia

Many fungal, bacterial and viral pathogens are transmitted on or within bean seed used by farmers for planting (Fig. 67). These pathogens can survive for long periods of time, and then infect and destroy the germinating seedling (Fig. 68), or survive as epiphytes on the developing plant until environmental conditions become favorable for infection later in the growing season. Seed storage life, seedling emergence and vigor, and plant yields can be seriously affected by these pathogens. There are three major control measures which can satisfactorily reduce the effects of seed transmission.

1. Varieties which are resistant or tolerant to infection by pathogens will prevent the buildup of pathogen spores or bacterial cells and assure the production of clean seed. However, varieties which are tolerant to infection may still exhibit some seed transmission which could provide inoculum for susceptible varieties; this seed should be handled by one or both of the following measures.

2. Various chemicals are available which can be applied as seed treatments to destroy pathogenic fungi and bacteria present on or within the seed. Some chemicals are systemic and can penetrate the seed coat to destroy internal contaminants, while other chemicals only disinfect the outer seed coat. Chemicals are also used to protect seed produced in the field. Foliar applications during the growing season, especially at pod formation and maturity, reduce the incidence of pod infection and seed contamination. Suitable chemicals for specific pathogens have already been mentioned in previous sections.

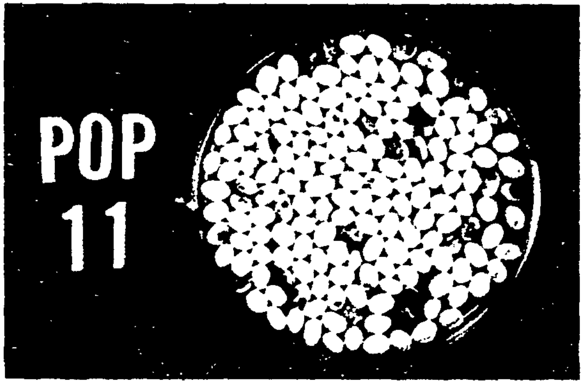


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Fig. 67

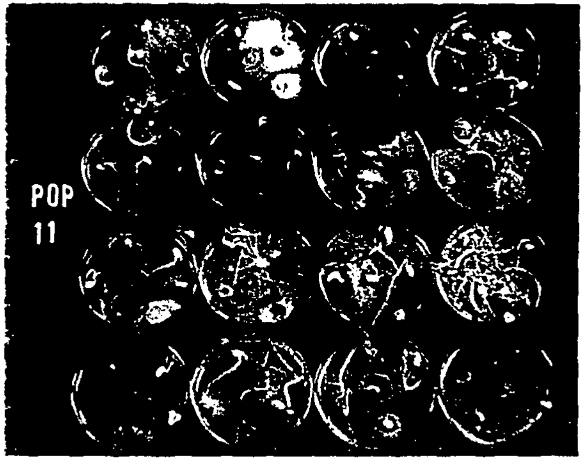

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Fig. 68

3. Production of pathogen-free seed can be easily achieved in areas where specific pathogens do not exist or where environmental conditions are unfavorable for pathogen development. However, this requires additional production costs and an efficient system to distribute the clean seed to farmers.

Many farmers, especially those working on a small scale, commonly keep seed over for future planting. If resistant or tolerant varieties are unavailable or chemicals are *not* used to treat this seed, several other simple practices are effective for reducing the incidence of seed-transmitted pathogens.

a. Harvesting should be as early as possible to reduce the period during which

Fig. 69

NOTES

the mature seed is exposed to pathogens and secondary contaminants (Fig. 69).

b. Only pods which are not in contact with the soil surface should be harvested for seed to be saved.

c. Only pods from plants which obviously were not infected by a pathogenic organism during the growing season should be harvested.

d. Seed which is not visibly damaged or discolored should be selected for storage and subsequent planting.

B. Insect Pests

Introduction

Beans may be attacked by many insect pests which cause defoliation, pod and seed losses on the plant, and storage losses. Beans in Latin America are often grown in association with other crops, and in diversified environments which tend to stabilize insect populations and maintain an equilibrium between pests and their biological control agents. Beans also have a relatively short growing season which usually enables the plants to escape significant damage and yield loss before insect populations reach serious levels.

However, these positive factors are often complicated by current agricultural practices such as continuous cropping and varietal uniformity. Abuses like poorly planned pesticide policies often destroy natural biological control agents or stimulate pests to develop tolerance to specific chemicals. Some insect pests are distributed throughout Latin America, while others are restricted to specific growing regions. Problems caused by these insects are described in the following sections.

9. Seedling Attacking Insects

NOTES

9.1 Crickets	Grillos
Millipedes	Ciempiés
Molecrickets	Grillotopo
Ants	Hormigas
Whitegrubs	Gallinaciegas
	Gusano Manteco

A large number of insects sporadically attack beans during and shortly after plant germination. Infestations of these insects are usually unpredictable and seldom cause serious or widespread damage.

Crickets usually sever primary leaves or growing points from stems (Fig. 70), while molecrickets and whitegrubs (Fig. 71) feed on underground plant parts causing seedling death. Millipedes and ants destroy seed prior to germination.

Control measures should rely upon insect baits placed near the base of the plants. A satisfactory bait formulation may include sawdust, cornmeal or wheat-bran, molasses and trichlorfon or disulfoton. It should be applied in the late afternoon.

A V SCHOONHOVEN

Fig. 70

CIAT

Fig. 71

9.2 Cutworms

Trozadores

Cortadores

Nocheros

NOTES

Agrotis ipsilon Hüfnagel — Rosquillas

Spodoptera frugiperda (J. E. Smith) — Lagarta Militar

Spodoptera eridania (Cramer) — Lagarta Rõsca

The larvae of many species of noctuid moths can damage bean seedlings. The adult moth lays eggs during the night on seedlings or organic matter. Larvae are usually gray-brown and can be found near the base of the plant a few centimeters deep in the soil where they feed subterraneously on the seedling stem and hypocotyl, severing the roots and stem and causing plant wilt and death (Fig. 72). Severe seedling losses may occur, especially in moist or humid areas of the field. Stem girdling (Fig. 73) may also occur in older plants which wilt (Fig. 74) or are broken by the wind. This damage is sometimes confused with that caused by root infecting fungi.

Bait formulations are effective control measures. Adequate soil preparation and removal of plant debris by burning or soil incorporation often reduces pest populations. Preventive chemical control is not feasible since attacks are infrequent and unpredictable.

Fig. 72

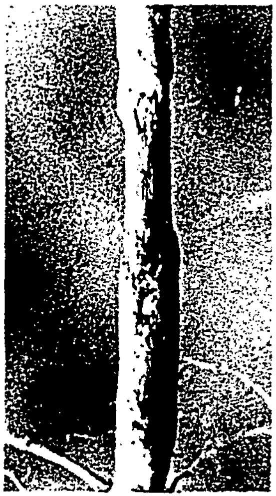


Fig. 73

Fig. 74

9.3 Lesser Corn Stalk Borer

Elasmopalpus lignosellus (Zeller)

Coralillo
Barrenador del Tallo
Elasmo
Lagarta Elasmo

NOTES

The lesser corn stalk borer can be a serious problem, especially in some areas of Peru and Brazil. The gray larvae (Fig. 75) enter the stem just below the soil surface and tunnel upwards into the seedling, causing plant death. Adults lay their eggs in the soil or on leaves, and larvae may form pupal chambers in soil attached to the stem (Fig. 76).

Control methods include clean fallowing and heavy irrigations. Chemical control (with methamidophos, monocrotophos or carbofuran) should be directed near the seeds or at the base of the seedlings.

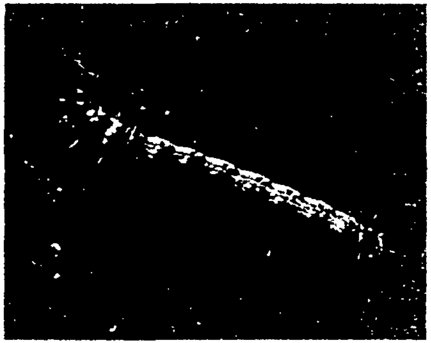


Fig. 75 (1.5 X)

Fig. 76

9.4 Seedcorn Maggot

Hylemya cilicrura (Rondani)

Hylemya liturata Meigen

Mosca de la Semilla

Mosca de la Raíz

Gusano de la Semilla

NOTES

The seedcorn maggot can severely reduce plant density in areas with moderate temperatures, such as Chile and México. Larvae (white maggots) attack the germinating seeds at the growing point (Fig. 77), and prevent germination or deform the seedlings (Fig. 78). Larvae can also penetrate the hypocotyl. Adult females, resembling the common housefly, lay their eggs in recently disturbed, humid soil high in organic matter.

Control is most easily achieved by planting later in the season when the soil temperature is higher and seeds germinate rapidly, thereby reducing the exposure time. Resistant varieties may also be planted, or the chemicals carbofuran or diazinon may be applied.

G BASCUR B

Fig. 77

G BASCUR B

Fig. 78

10. Leaf Eating Insects

NOTES

10.1 Caterpillars

Estigmene acrea (Drury)	Gusano Peludo
Hedylepta indicata. (F.)	Telarañero, Pega Hojas
Trichoplusia ni (Hübner)	Falso Medidor
Urbanus proteus (L.)	Gusano Cabezón
	Gusano Fósforo

Several species of caterpillars cause defoliation of bean plants. Yields are usually not greatly reduced unless defoliation is severe due to larval feeding. Young larvae of *E. acrea* aggregate (Fig. 79), are recognized by their hairiness (Fig. 80) and may vary in color from light-brown to black. Those of *U. proteus* are easily identified by their relatively large red-brown head capsule (Fig. 81). Feeding damage of *U. proteus* is evident as folded leaf sections (Fig. 82), beneath which the larvae live. Larvae of *Hedylepta* sp. are green, and feed on leaf parenchyma tissue of leaves woven together (Fig. 83). *Trichoplusia* larvae are pale green loopers which may damage pods and directly reduce yields (Fig. 84).

Biological control is usually present since high levels of parasitism of larval stages occurs naturally unless broad-spectrum insecticides have been applied. *Bacillus thuringiensis* is a bacterium which is effective when sprayed onto bean plants to control the larvae. *Trichogramma* egg parasites can also be released in the vicinity of infested plants. Chemical control (using endosulfan) is possible, however, it is difficult to reach larvae hidden between leaves which are woven together.

Fig. 79

Fig. 80

Fig. 83


Fig. 81


Fig. 82

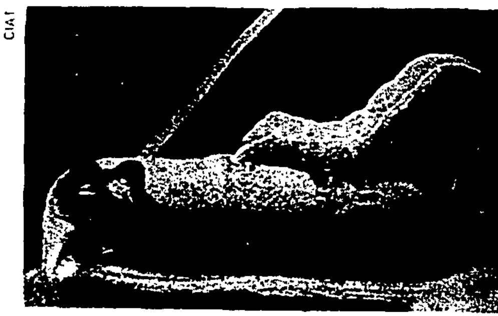


Fig. 84

10.2 Chrysomelids

Crisomélidos

NOTES

Cucarroncitos de las Hojas

Diabroticas

Doradillas

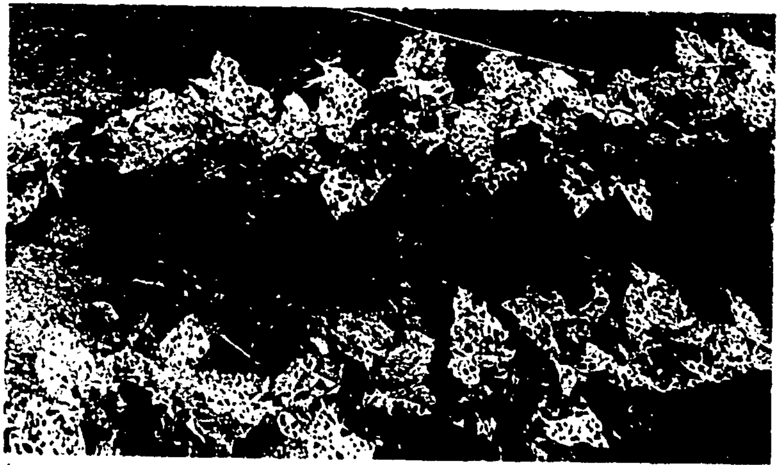
Cerotoma facialis (Erichson) — Tortuguillas

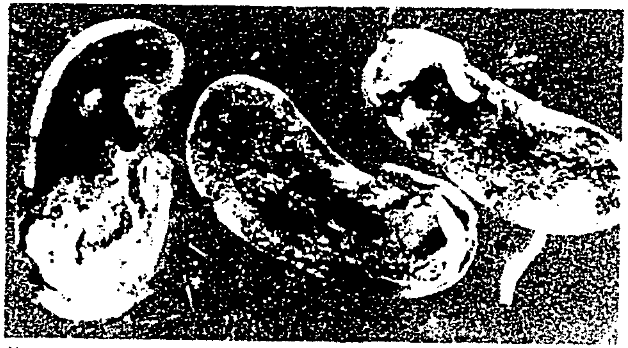
Diabrotica balteata LeConte — Vaquitas

Neobrotica sp. — Vaquinhas

Adult chrysomelid beetles vary in color according to the species (Fig. 85). All are about 1 cm in length. These insects are widely distributed throughout bean production regions and can transmit bean rugose mosaic virus. Adults can cause defoliation during the entire growth cycle of beans, however, certain amounts of foliage damage can be tolerated before yield losses become serious. Seedling damage is usually more severe (Fig. 86), while flower and young pod damage also occur. Larvae feed on plant roots and root nodules, leaving feeding marks (Fig. 87) or perforations resembling adult feeding damage. Plants with severe root damage are stunted, and basal leaves turn yellow with premature senescence.

Adult feeding is controlled with foliar applications of carbaryl or diazinon while band applications of carbofuran are effective against larval feeding.





10.3 Mexican Bean Beetles

Conchuelas

NOTES

Epilachna varivestis Mulsant

The Mexican bean beetle is a serious pest of beans in many regions of Central and North America. Adults are 5 mm in length and copper-colored with 16 black spots on their back (Fig. 88). Larvae are yellow and covered with branched spines (Fig. 89). Adult beetles and larvae can cause serious defoliation as adults feed throughout the entire leaf, while larvae feed on the lower leaf surface usually leaving the upper epidermis intact. Larvae chew and compress the leaf tissue but only swallow the plant juices. Stems and young pods may also be damaged. Adult females attach yellow to orange-colored eggs to the lower leaf surface, and mature larvae pupate while attached to the leaf.

Control measures include destroying or deep plowing of plant debris, reducing plant density, planting resistant varieties or applying chemicals (carbaryl, disulfoton or malathion). Chemical control can often be combined with the first spray application for *Apion* attack (see Section 12.1).

10.4 Leafminers — Minadores

Agromyza sp.
Liriomyza sp.

NOTES

Leafminers are often abundant, but generally do not reduce yields. The larval damage appears as serpentine galleries (Fig. 90) and the pupae can be found attached to the leaf (Fig. 91).

Control measures are not economically justified.

10.5 Slugs — Babosas, Lesmas

Vaginulus plebejus Fisher
Limax maximus (L.)

While they are not insects, slugs cause serious defoliation of beans, especially in El Salvador and Honduras. Mature and young slugs are cylindrical, flattened, lack legs and have a brownish-gray body which is soft and slimy (Fig. 92). Mature slugs may measure 10 cm in length. The hermaphroditic adults lay egg masses in moist environments beneath plant debris or weeds, and young slugs mature in about three months. They feed on foliage during the night, and hide beneath plant debris and weeds during the day.

Control measures include removal of weeds from field borders, destruction of plant debris and application of commercial baits.

A. V. SCHOONHOVEN

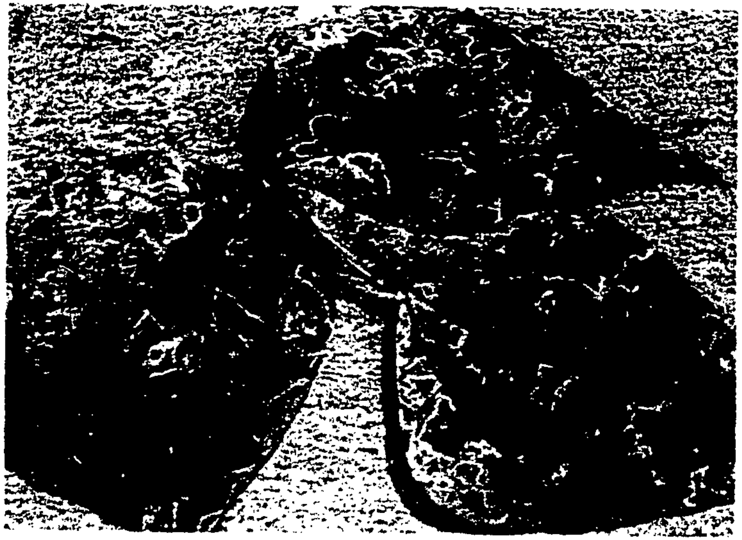


Fig. 90

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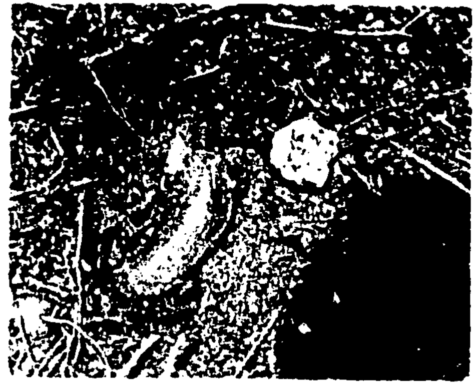

Fig. 92

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Fig. 91 (2.5 X)

11. Leaf Piercing Insects

NOTES

11.1 Aphids

	Afidos
Aphis gossypii Glover	Pulgones
Aphis medicaginis Koch	Afidios
Brevicoryne brassicae (L.)	Pulgão do Feijoeiro

Several species of aphids attack bean plants. Their feeding seldom causes direct damage to the plant, but some species are able to transmit virus particles of bean common mosaic virus or bean yellow mosaic virus. Aphids are small (2 mm) and green to black in color (Fig. 93), depending upon the species. Aphids may be winged or wingless depending upon age and density of insect populations. Aphid populations can expand rapidly since females are viviparous.

Natural predators such as lady beetles and some dipterous larvae (syrphids) constitute effective control measures. Applications of malathion or pirimicarb are also effective.

Fig. 93 (5 X)

11.2 Leafhoppers

Chicharritas

Lorito Verde

Cigarra

Saltahojas

Empoasca kraemeri Ross and Moore

Cigarrinha Verde

NOTES

The leafhopper is one of the most economically important insect pests of beans; it often causes complete crop losses. Adults, measuring about 3 mm (Fig. 94), and pale green nymphs (Fig. 95) feed on leaf undersides and petioles. Leafhopper damage is apparent on leaves which have yellowed margins and cup or curl downwards (Fig. 96). Plants are stunted and have a bushy appearance. Beans are most sensitive to leafhopper attack during the flowering stage.

Control measures include planting during the wet season, and use of mulches, associated cropping and resistant varieties. Chemical control is achieved with seed, side-dressing or foliar applications of chemicals such as carbaryl, dimethoate or monocrotophos.

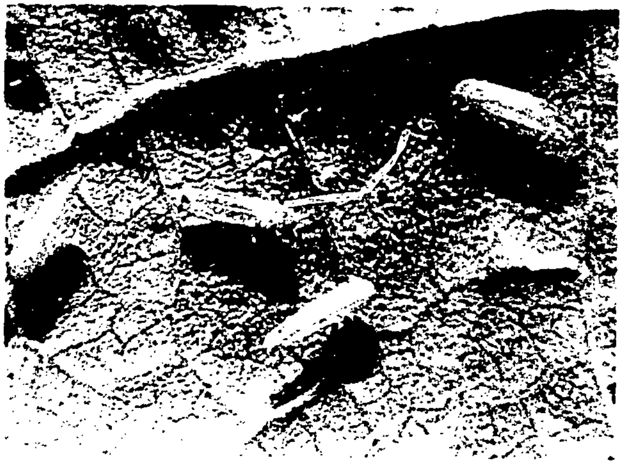


Fig. 94 (6 X)

Fig. 95 (6 X)

Fig. 96

NOTES

11.3 Mites

Mites	Acaros
Red Spider Mite	Arañita Roja
Tetranychus desertorum Banks	Acaro Rajado
Tetranychus urticae Koch	
Tarsonemid Mite	Acaro Blanco
	Acaro Branco
Polyphagotarsonemus latus Banks	Acaro Tropical

Mites do not usually cause significant damage but can become serious during the dry season and following heavy applications of pesticides. The red spider mite is found on the lower leaf surface (Fig. 97), and is identified by small red or brown spots on its abdomen. Feeding damage may be observed as a cluster of pinpoint sized white dots on the upper leaf surface (Fig. 98). Continued feeding causes the leaves to turn rust-brown in color and become covered by webbing (Fig. 99). The tarsonemid mite is a small, pale green mite which is not visible without magnification. This mite causes the edges of young leaves to roll upwards (Fig. 100); leaves often exhibit a reddish-purple discoloration on the lower surface (Fig. 101). Continued feeding may cause leaves to turn yellow and fall prematurely. Heavy feeding may also discolor the pods.

Control measures for the red spider mite include planting in the wet season, using uniform planting dates and resistant varieties, and the judicious use of chemicals (carbaryl, monocrotophos, endosulfan or Elosal). Tarsonemid mites are controlled by the chemicals.

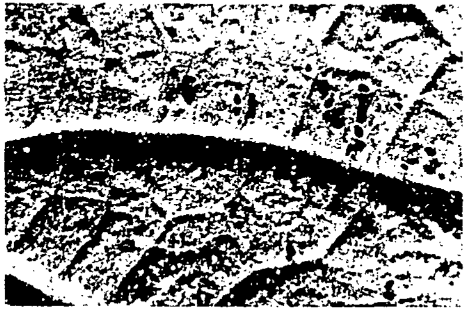


Fig. 97 ×2.5 X

Fig. 99

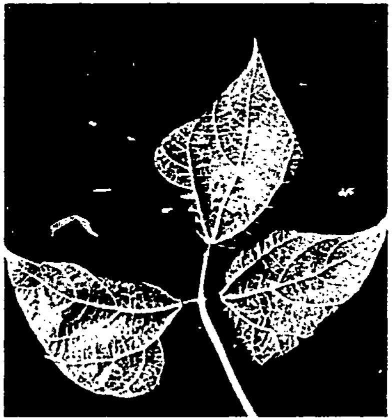


Fig. 101

Fig. 98

Fig. 100

11.4 Whiteflies

Mosca Blanca

Mosca Branca

NOTES

Bemisia tabaci Glennadius

Trialeurodes vaporariorum (Westwood)

Several species of whiteflies attack bean plants. Their feeding seldom causes direct damage to the plant, but some species and strains are able to transmit virus particles of bean golden mosaic virus and bean chlorotic mottle virus. Adults are small white insects (Fig. 102), about 2-3 mm in length, which often fly up in a cloud-like mass when the plant is disturbed. Immature stages are oblong, pale green, and attached to the leaf underside (Fig. 103).

Whiteflies are controlled by natural predators and parasites, or by applications of oxydemeton-methyl, monocrotophos, phorate or aldicarb.

Fig. 102 (0.5 X)

Fig. 103 (4 X)

12. Pod Attacking Insects

NOTES

12.1 Bean Pod Weevil

Picudo de la Vaina

Apion godmani Wagn.

Picudo del Ejote

The bean pod weevil is a serious pest in Central America and can cause complete yield loss when larval feeding is heavy. The adult weevil, which is black and nearly 2 mm in length, feeds on flowers and pods with no appreciable damage. The adult female chews a small hole in the mesocarp of small pods and deposits an egg on or above the developing seed. This damage appears as a scar on the developing pod (Fig. 104). Larvae, white rounded grubs a few millimeters long, feed down the pod wall to the developing seed which then serves as a feeding chamber (Fig. 105). The larvae pupate in the pods and adults emerge when the pods approach maturity.

Control measures include timely planting (around May in Central America), development of resistant varieties and application of the chemicals carbofuran, carbaryl, or monocrotophos.


A V SCHOONHOVEN

Fig. 104

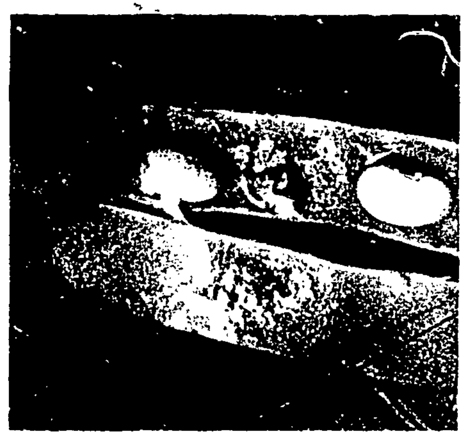

A V SCHOONHOVEN

Fig. 105

12.2 Epinotia — Polilla del Frijol

Epinotia opposita Heinrich — Barrenador de la Vaina

NOTES

Epinotia sp. are lepidopterous pod borers which can be economically important in Peru, Chile and Brazil. Young larvae are green while older larval stages appear pink. Larvae push masses of black excrement out of their larval tunnels onto the plant surface. Larvae feed on terminal and lateral buds (Fig. 106), or perforate stems and pods. Secondary rotting often accompanies the feeding damage in pods.

Control measures include early planting and application of the chemicals carbaryl, monocrotophos or methamidophos.

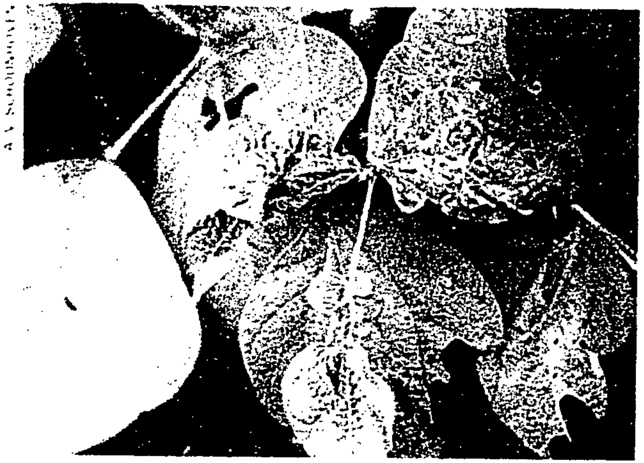


Fig. 106

12.3 Corn Ear Worm

Heliothis
Helotero
Bellotero
Yojota

NOTES

Heliothis virescens (F.)

Heliothis zea (Boddie)

Heliothis sp. may cause sporadic but severe damage to beans. Larvae are greenish-yellow with longitudinal bands which are often reddish-brown in color. Adults lay their eggs on young bean leaves, and larvae feed on flowers and developing seeds in the pods by perforating the pod wall directly above the seed (Fig. 107). The larvae do not tunnel inside the pod but can destroy several seeds in each pod. Secondary rotting often accompanies this feeding and destroys the remaining seeds.

Control measures include the use of *Trichogramma* egg parasites, or the *Bacillus thuringiensis* bacterial pathogen on young larvae. The chemicals monocrotophos or methomyl are also effective controls.

12.4 Other Pod Borers

Otros barrenadores de las Vainas

NOTES

Maruca testulalis (Geyer)

Laspeyresia leguminis (Heinrich)

Other pod-boring insects are encountered in many regions of Latin America. *Maruca* sp. lay eggs near or on flower buds, flowers, young leaves and pods. Damage usually results from pod-boring followed by secondary rotting. *Laspeyresia* sp. cause damage similar to that of *Epinotia*, however, this borer usually webs pods together. Adults lay eggs on pods where young larvae bore into them and destroy the seeds (Fig. 108).

Control measures include early planting and application of the chemicals aminocarb or dimethoate.

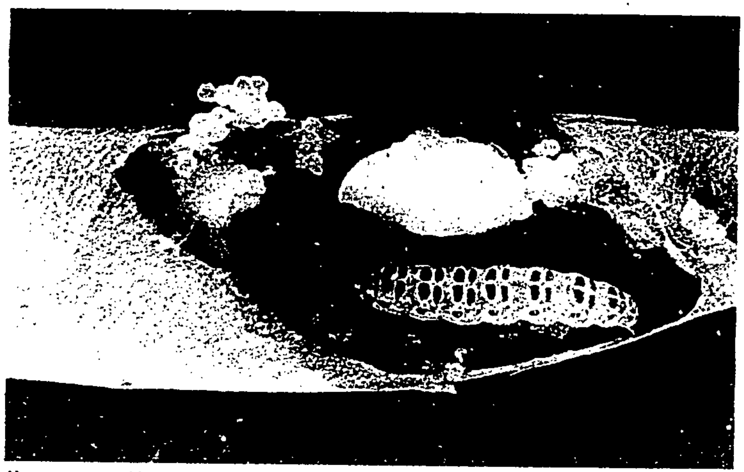


Fig. 108 (3 X)

13. Stored Grain Insects

NOTES

13.1 Bruchids

Gorgojo

Gorgojo Común del Fríjol

Carunchos

Acanthoscelides obtectus (Say) — Gorgulho de Feijão

Acanthoscelides obtectus is the principal stored grain insect in cool highland regions of Latin America or in less tropical countries such as Argentina, Chile and Mexico. Adults are gray-brown and measure 3 mm (Fig. 109). Females lay eggs among stored seed or infest beans in the field where they lay eggs in cracks or wounds of developing pods. Young larvae then penetrate the seed which serves as the feeding and pupation cell. This cell becomes visible as a circular window where the larvae feed on the lower surface on the testa. After pupation the adult pushes or cuts this tissue out and repeats the egg laying cycle immediately after emergence.

Control measures include dusting stored, shelled beans with inert materials such as crystalline silica, bentonite or magnesium carbonate or protecting stored seed with the chemicals phostoxin or pyrethrins. Seed can also be protected with vegetable oils and resistant varieties are available.

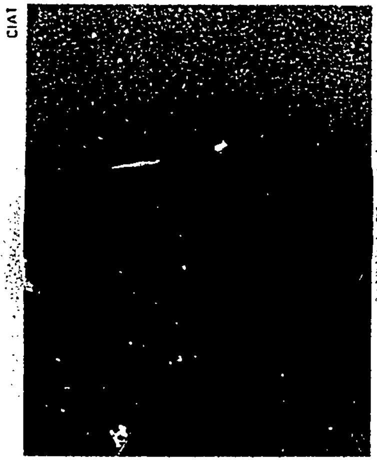


Fig. 109 (3 X)

13.2 Bruchids

Gorgojo Pintado

Carunchos

Zabrotes subfasciatus Boheman

Gorgulho de Feijão

NOTES

Zabrotes subfasciatus is the principal pest of stored grain in warmer regions (usually below 1500 m) of the tropics . Adult females are grayish-brown with lighter colored spots on the abdomen. Adult males (about 3 mm long) are one-half the size of females and are uniformly gray-brown in color. *Zabrotes* females lay eggs and firmly attach them to the seed (Fig. 110). The larvae then hatch and bore through the egg shell and seed coat in one process. The remainder of the life cycle is similar to that of *Acanthoscelides obtectus.*

Control measures include storing beans in undamaged pods and treating seeds either with vegetable oils or chemicals (phostoxin or pyrethrins).

Fig. 110 (4 X)

C. Nutritional Disorders

Introduction

In Latin America beans are grown on many different soil types where different nutritional dificiencies or toxicities may limit yield. In Central America and western South America, beans are generally grown in mountain areas where Andosols (Inceptisols) predominate. In these soils phosphorus deficiency and aluminium/manganese toxicity are the main problems. Between mountain ranges, beans are grown in valleys which generally have alluvial soils of high fertility, but sometimes are low in minor elements. In many parts of Venezuela and Brazil, beans are grown on rather acid, low fertility Oxisols and Ultisols. Phosphorus deficiency and aluminium toxicity are the main limiting factors, but zinc deficiency also occurs.

Although beans extract rather large amounts of nitrogen and potassium from the soil, the most common nutritional problem is phosphorus deficiency. Nitrogen deficiency may also seriously limit yields in low organic matter soils or in soils where biological nitrogen fixation is not effective due to high temperatures or soil restrictions. Potassium deficiency seldom occurs in Latin America. Beans are extremely susceptible to aluminium/manganese toxicity which frequently occurs in acidic soils. Among the minor element problems, boron and zinc deficiency are most commonly observed in high-pH soils or soils with a very low content of weatherable minerals.

A nutritional problem is generally diagnosed with the use of soil and plant tissue analyses, as well as visual observation of symptoms. Sometimes a range of different elements is applied to either soil or foliage to observe any improvement of growth or disappearance of symptoms, so as to identify the specific element limiting plant growth.

14.1 Aluminium (Al) Toxicity

Toxicidad de Aluminio
Toxicidade de Aluminio

NOTES

Aluminium toxicity occurs in large areas of Latin America with acid Oxisols, Ultisols and Inceptisols. Beans are quite susceptible to aluminium toxicity and generally do not yield well in these soils unless lime is added. Bean yields are affected if the aluminium saturation of the effective Cation Exchange Capacity is over 25 to 30 percent. Aluminium toxicity produces stunted growth and necrosis along leaf margins (Fig. 111). Under severe conditions all leaves senesce and the plant dies (Fig. 112, left side).

Aluminium toxicity is controlled by applying calcitic or dolomitic lime. Six tons lime/ha was effective on an acidic volcanic ash soil as indicated by improved plant growth (Fig. 113, background). Application of basic slag and certain rock phosphates may also reduce aluminium toxicity, while such acid-forming fertilizers as ammonium sulphate and urea may intensify the problem.

Fig. 111

Fig. 112

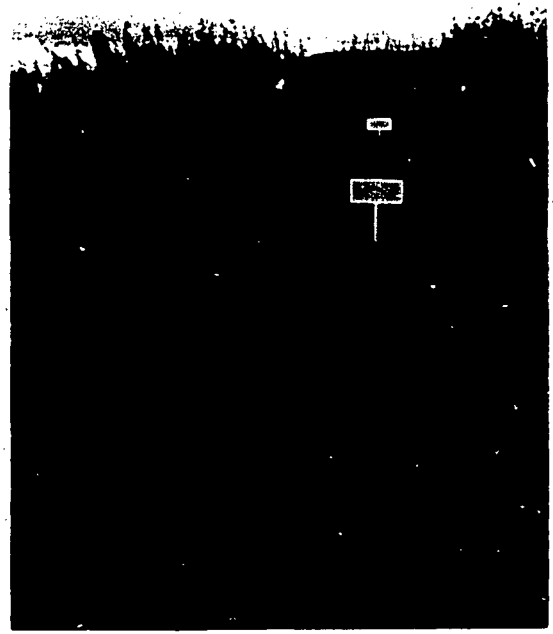


Fig. 113

14.2 Boron (B) Deficiency and Toxicity

Deficiencia y Toxicidad de Boro

Deficiencia e Toxicidade de Boro

NOTES

Boron deficiency is most common on coarse-textured soils, low in organic matter and high in hydroxides of aluminium and iron. It is also observed in high-pH alluvial soils with low total boron contents. Deficient plants have thick stems and leaves with yellow and necrotic spots (Fig. 114 and 115); leaves may be crinkled and turned downward, and terminal buds often die and lateral buds proliferate. Under conditions of severe boron deficiency, plants remain stunted or die shortly after germination (Fig. 116, left side). Deficient plants have boron contents of less than 25 ppm in their upper leaves, while deficient soils generally contain less than 0.6 ppm of hot-water extractable boron. Black beans appear more susceptible to boron deficiency than red beans.

Boron deficiency can be controlled by soil application of 1-2 kg boron/ha as Borax, Solubor or other sodium borates at planting. Higher application rates may result in toxicity. Foliar application of 1 percent Solubor or 2 percent Borax at two and four weeks is recommended when the deficiency is not extremely severe.

Boron toxicity causes yellowing and necrotic borders of primary leaves shortly after emergence (Fig. 117). It generally occurs after non-uniform application of fertilizer or when the fertilizer is band-applied too closely to the seed, especially during dry weather.

C FLOR

Fig. 114

C FLOR

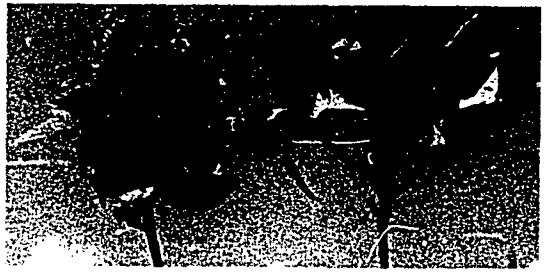


Fig. 115

C FLOR

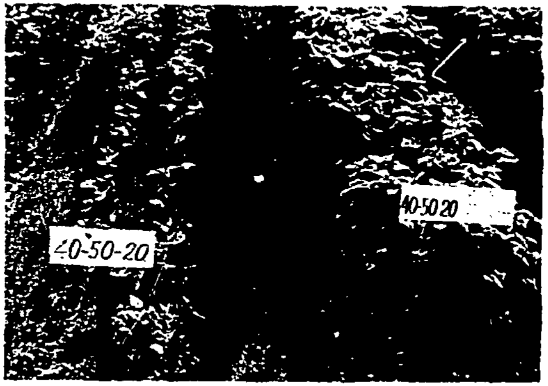


Fig. 116

C FLOR

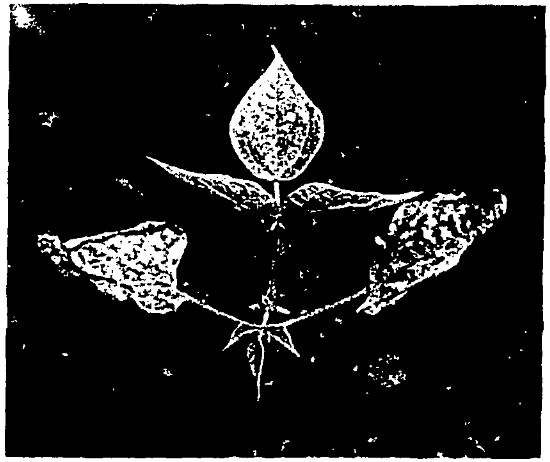


Fig. 117

14.3 Calcium (Ca) Deficiency

Deficiencia de Calcio

NOTES

Calcium deficiency is generally observed in combination with aluminium toxicity in acid Oxisols and Ultisols. Calcium deficient plants remain small with a poorly developed root system (Fig. 118, right side). Leaves remain green with a slight yellowing at the margins and tips, and may crinkle and curl downwards. Internodes are often short, producing a rosette-type of plant growth (Fig. 119). Deficient plants have calcium contents in upper leaves of less than 2 percent at flower initiation.

Calcium deficiency is controlled by deep incorporation of calcitic or dolomitic lime, or calcium oxide or hydroxide. Low rates such as 500 kg/ha generally are sufficient to relieve calcium deficiency, but higher rates are often employed to neutralize toxic amounts of aluminium. Calcium phosphate sources such as basic slag, rock phosphate and superphosphate may contribute significantly to calcium nutrition.

Fig. 118

Fig. 119

14.4 Copper (Cu) Deficiency

Deficiencia de Cobre

NOTES

Copper deficiency occurs mainly in organic or very sandy soils. Deficient plants are stunted and young leaves become gray or blue-green with shortened internodes. Beans are relatively insensitive to copper deficiency. Normal plants have copper contents of 15-25 ppm in upper leaves.

Copper deficiency is generally controlled by soil application of 5-10 kg copper/ha as copper sulfate. Foliar applications of 0.1 percent copper as copper sulfate or copper chelates are also effective.

14.5 Iron (Fe) Deficiency

Deficiencia de Hierro

Deficiencia de Ferro

Iron deficiency may occur in organic soils or mineral soils with high pH, especially if free calcium carbonate is present. Deficiency symptoms appear as an interveinal chlorosis of upper leaves which later may become uniformly light yellow to white (Fig. 120). Normal iron levels are about 100-800 ppm.

The deficiency is controlled by foliar application of iron chelates.

14.6 Magnesium (Mg) Deficiency

Deficiencia de Magnesio

NOTES

Magnesium deficiency may occur in acid infertile soils with low base status or in soils high in calcium or potassium. Interveinal chlorosis and necrosis appear first on older leaves (Fig. 121 and 122), later spreading over the entire leaf and to younger foliage (Fig. 123). Deficient plants have magnesium contents in the upper leaves of less than 0.3 percent at flower initiation.

Magnesium deficiency is controlled by incorporating dolomitic lime or magnesium oxide, or by band application of 10-25 kg magnesium/ha as magnesium sulfate. Foliar sprays of magnesium sulfate or magnesium chelates may also be used.

Fig. 121

Fig. 123

Fig. 122

14.7 Manganese (Mn) Deficiency and Toxicity

Deficiencia y Toxicidad de Manganeso

Deficiencia e Toxicidade de Manganés

NOTES

Manganese deficiency may occur in organic soils or high-pH mineral soils. Deficient plants are stunted and upper leaves become golden yellow between small veins giving a mottled appearance on beans and soybeans (Fig. 124). Normal plants have manganese contents of 75-200 ppm in upper leaves, while deficient leaves generally contain less than 30 ppm.

The deficiency is controlled by soil application of 5-10 kg manganese/ha as manganese sulfate or manganous oxide, or by foliar applications of manganese chelates.

Manganese toxicity is common on very acid, poorly drained soils. Beans are quite susceptible to manganese toxicity and plants show an interveinal chlorosis of upper leaves (Fig. 125). With severe toxicity, upper leaves are small, crinkle and curl downwards (Fig. 126). Leaves generally contain over 500 ppm manganese.

The toxicity is controlled by liming and by improving field drainage.

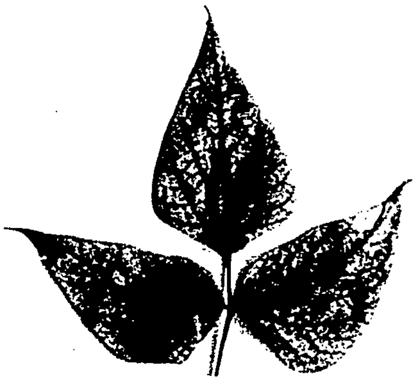


Fig. 124

Fig. 125

Fig. 126

14.8 Nitrogen (N) Deficiency

Deficiencia de Nitrógeno

Deficiencia de Nitrogenio

NOTES

Nitrogen deficiency is common in soils with a low organic matter content, and in acidic soils with toxic levels of aluminium or manganese, or deficient levels of calcium and phosphate which reduce effective bacterial nitrogen fixation. Leaves near the bottom of the plant turn pale green and eventually, uniformly yellow with discoloration gradually progressing upwards (Fig. 127). Plant growth is stunted and yields may be affected. Upper leaves of deficient plants contain less than 3 percent nitrogen during flower initiation, while a normal plant contains about 5 percent.

Nitrogen deficiency is controlled by inoculating seed with effective strains of nitrogen-fixing bacteria, or by applying a green manure, animal manure or chemical nitrogen fertilizers. The application of 50-100 kg nitrogen/ha is generally sufficient, although in some soils responses have been obtained with 200-400 kg nitrogen/ha (Fig. 128, left side). Nitrogen fertilizers are generally band-applied at or shortly after seeding, or as a split application at seeding and flower initiation. Ammonium or nitrate sources are equally effective.

Fig. 127

Fig. 128

14.9 Phosphorus (P) Deficiency

Deficiencia de Fósforo

NOTES

Phosphorus deficiency in beans is common on volcanic ash soils and in highly weathered Oxisols and Ultisols. Plants lack general vigor and have few side branches (Fig. 129, left side). Upper leaves are dark green but small, and bottom leaves become yellow and necrotic before senescing (Fig. 130). Phosphorus deficiency retards flowering and maturation (Fig. 131). Deficient plants have less than 0.35 percent phosphorus in upper leaves at flower initiation.

Phosphorus deficiency is controlled by applying, at the time of planting, bone meal, basic slag, single or triple superphosphate or rock phosphates. These treatments should be broadcast and incorporated except for the superphosphate which should be applied in bands in high phosphorus-fixing soils. The rate of application depends on the phosphorus content of the soils and its phosphorus-fixing capacity. High rates of 200-400 kg P_2O_5/ha of a phosphoric acid fertilizer are required for maximum yield in high phosphorus-fixing soils (Fig. 132, left side).


R HOWELER

Fig. 129


R HOWELER

Fig. 130


C FLOR

Fig. 131


C FLOR

Fig. 132

14.10 Potassium (K) Deficiency

Deficiencia de Potasio

Deficiencia de Potássio

NOTES

Potassium deficiency seldom is observed in beans, but can occur in infertile Oxisols and Utisols, or in soils high in calcium and magnesium. Symptoms appear as yellowing and necrosis of leaf tips and margins, initially on the lower part of the plant, but gradually extending upwards (Fig. 133). Necrotic spotting may also occur. Deficient plants have less than 2 percent potassium in upper leaves at flower initiation, and this level may be lower in plants grown on high calcium or magnesium soils.

Potassium deficiency is generally controlled by banding, at the time of planting, 50-100 kg potash (K_2O)/ha in the form of either potassium chloride or potassium sulfate. The sulfate form is recommended for soils which are low in available sulphur.

Fig. 133

14.11 Sulphur (S) Deficiency

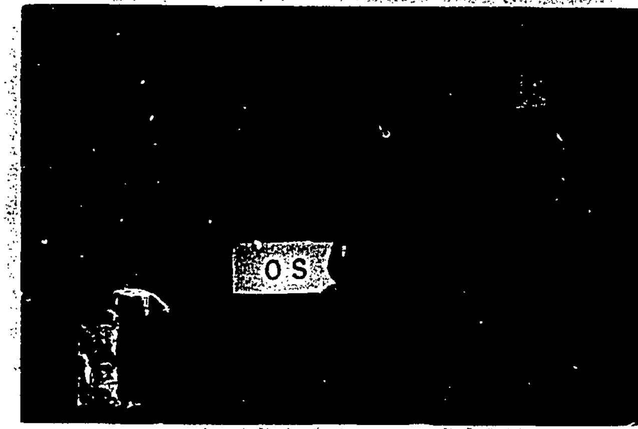
Deficiencia de Azufre

Deficiencia de Enxõfre

NOTES

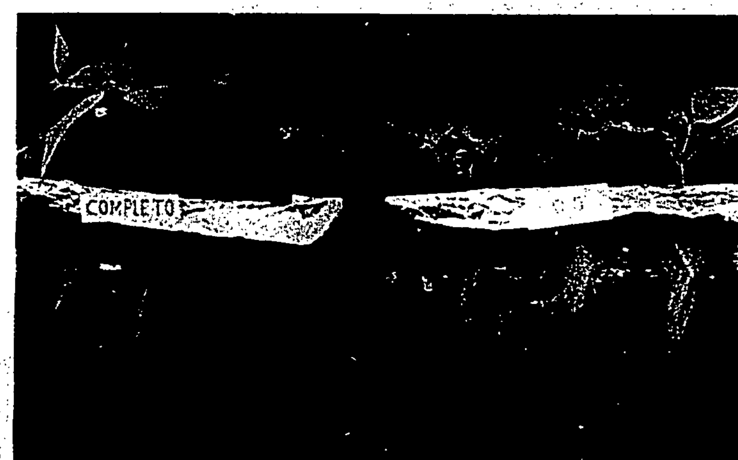
Sulphur deficiency may occur in infertile Oxisols and Ultisols, especially those far removed from industrial centers. Upper leaves become uniformly yellow and resemble leaves with nitrogen deficiency symptoms (Fig. 134). Unlike calcium deficiency, root growth is not greatly affected (Fig. 135, right side). Deficient plants have less than 0.15 percent sulphur in upper leaves at flower initiation.

Sulphur deficiency is controlled by applying 10-20 kg/ha of elemental sulphur, or the use of sulfur-containing fertilizers such as simple superphosphate, ammonium and potassium sulphates. Certain fungicides such as Elosal may contribute to the sulfur nutrition of the plant.



CIAT

Fig. 134



CIAT

Fig. 135

14.12 Zinc (Zn) Deficiency

Deficiencia de Zinc

Deficiencia de Zinco

NOTES

Zinc deficiency occurs in high-pH soils or over-limed acid soils with low zinc content. It may be induced by high application of phosphorus. Zinc deficiency symptoms appear as an interveinal chlorosis of upper leaves (Fig. 136), which later become necrotic (Fig. 137). Deficient plants have zinc contents below 20 ppm in the leaves, while normal levels are about 40-50 ppm.

Zinc deficiency can be controlled by soil application of 5-10 kg zinc/ha as zinc sulfate, or by foliar sprays of 0.5 percent zinc sulfate or zinc chelates.

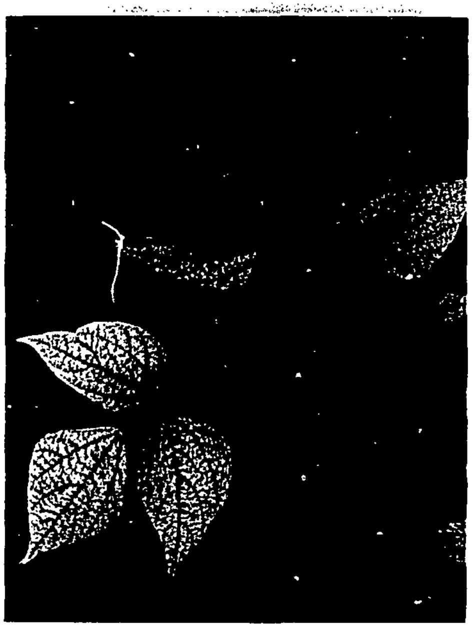


Fig. 136

Fig. 137

D. Miscellaneous Production Problems

Introduction

Many other factors besides plant pathogens, insects, and nutritional disorders may sporadically but severely damage beans during their growth. Various environmental conditions such as frost, high temperature, wind, drought, etc. can injure plants. Variation in soil properties, drainage, etc. may produce marked differences in plant appearance and vigor within localized areas of a field. Improper management may result in mechanical and/or chemical damage. Proximity to industrial centers may also result in chemical damage which is induced by toxic air pollutants. Symptoms induced by these types of factors are sometimes confused with those caused by pathogens, insects or nutritional disorders, therefore, it is often necessary to consult trained personnel who can differentiate between these causative agents.

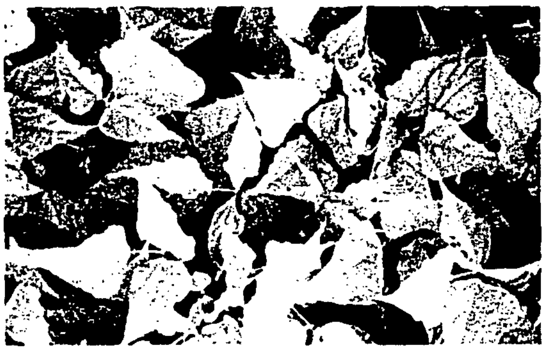
15.1 Chemical Damage

Daño Químico

NOTES

Chemical damage may affect beans during the growing season, especially during germination and seedling development, if chemicals are not applied according to manufacturer's recommendations. Toxic concentrations of chemical and fertilizer may be placed too close to seeds, creating problems if chemicals do not dissolve and leach rapidly into the root zone. Damage symptoms include brown or necrotic tissue on the leaves, usually at the leaf tips and margins (Fig. 138). Depending upon the severity of damage, leaves may be deformed and stunted in their development. Foliage burn can also occur as necrotic spots (Fig. 139) if toxic chemical sprays drift onto bean plants. For example, 2,4-D damage may occur if applied to other crops nearby during moderate to high winds (Fig. 140). Physiological disorders can be caused by other chemicals which may contain impurities or products metabolized by soil microorganisms into toxic by-products, or aggravated by specific soil and environmental conditions. It is believed that CIAT recently encountered a similar situation in beans, called "Problem X", which may be caused by chemical toxicity in soils with a high organic matter content and high pH (Fig. 141 and 142).

Fig. 140



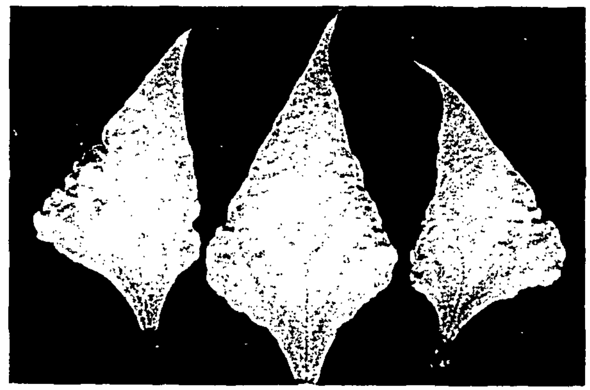


Fig. 142

15.2 Environmental Factors

Factores Ambientales

NOTES

Various environmental factors can affect beans during their development. Prolonged exposure to excess soil moisture or standing water induce plant chlorosis and zinc deficiency. Extreme heat and lack of moisture can induce plant wilt, scorched leaves and even plant death. High winds and wind-blown soil particles can damage plants by tearing and abrading the tissue (Fig. 143). Such wounds often provide sites of entry for plant pathogens such as bacteria. Sunscald can occur on leaves or pods when tissue is covered by water droplets or saturated with moisture and exposed to intense sunlight and/or heat, resulting in brown necrotic patches on leaves, stems or pods (Fig. 144).

15.3 Genetic Abnormalities

Anormalidades Genéticas

Beans are occasionally affected by various genetic abnormalities which may result from mutation, incompatibility or cytoplasmic irregularities. Examples include albino plants which lack chlorophyll and usually die within a few days after emergence. Leaf variegations may be observed in populations of segregating progeny and are recognized by mosaic patterns of green, yellow and/or white tissue (Fig. 145 and 146). This condition often causes malformed leaflets; pods produced by such plants may also be misshapen. These symptoms may appear at different stages of plant development and variegated leaves are often present on plants which also have normal-appearing leaves.

Fig. [illegible]

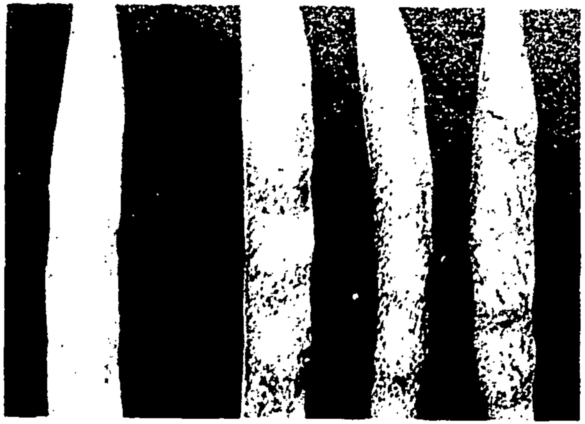
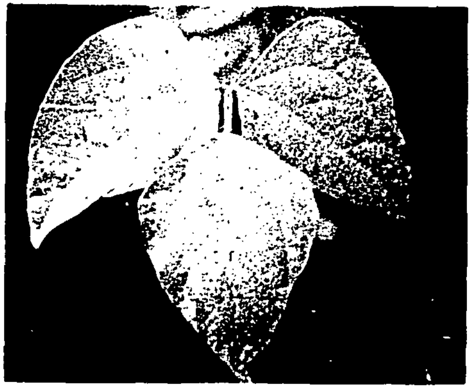


Fig. [illegible]

Fig. [illegible]



H. F. SCHWARTZ

Fig. 146

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Index of Scientific Names For Plant Pathogens and Insect Pests

Research by and collaboration between
national and international programs

will lead to increased productivity
of field beans in Latin America