BEAN DISEASE AND PEST IDENTIFICATION AND MANAGEMENT

HANDBOOKS FOR SMALL-SCALE SEED PRODUCERS

CIAT

Pan-Africa Bean Research Alliance
PABRA

HANDBOOK FOUR

The International Center for Tropical Agriculture (CIAT) is a not-for-profit organization that works to reduce hunger and poverty, and improve human health in the tropics through research aimed at increasing the eco-efficiency of agriculture. CIAT is one of 15 centers funded by the 64 countries, private foundations, and international organizations that make up the Consultative Group on International Agricultural Research (CGIAR).

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This publication was developed by the
International Centre for Tropical Agriculture (CIAT)

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CONTENTS

FOREWORD

The production of the common bean (*Phaseolus vulgaris L*) is influenced by many biotic and abiotic factors that interact during its growing cycle. Diseases are some of the major biotic factors affecting bean production. Most of the organisms causing these diseases are seed-borne arising from external contamination or by being carried in the seed. Seed-borne diseases result in poor germination, poor plant vigour, low yield and poor quality seed. Certain insect pests also affect seed quality and plant emergence through the damage they cause to seed in the field and storage. Some transmit and spread disease causing organisms in the field. Others directly attack seedlings, causing significant reductions in plant stand and yield. The predominant amount of bean seed utilised by small-scale farmers comes from regular crop harvest meant for food, and where limited pest and disease management practices are used. Hence varying levels of seed borne infection can be expected which could lead to diseased subsequent crops depending on season, type of disease and management practices used. A build up of seed borne infection over time necessitates replacement of seed using clean or health seed.

Most farmers use "farm-saved" seed (bean is a self pollinated crop and does not easily degenerate genetically) or that produced by neighbours or farmer groups (informally). Consequently, few seed companies (formal sector) are keen to produce bean seed resulting in the little available certified seed being expensive and less accessible to most rural farmers.

It has been shown and documented in a number of countries that with some technical support, farmers can produce clean and potentially certifiable seed. This can help in reducing the cost of seed and bean production; enhance accessibility of good quality seed in a timely manner and facilitate faster dissemination of improved and local varieties. This manual is aimed at contributing towards enhancing the capacity of different actors, particularly small scale seed producers in seed production, by describing common pests and diseases and their management.

Please note that, for most diseases, no single disease management measure will prevent disease infection, but integration of different

management practices can provide long-term and reliable protection for the crop. The resistant varieties suggested in this manual may not be adapted to all environments. We encourage bean growers to seek more information on the available varieties in their countries.

OBJECTIVES OF THIS MANUAL

1. To facilitate bean growers in the recognition of common diseases and pests of beans and conditions under which they occur.
2. To highlight and sensitise farmers and/or small scale seed enterprises on possible disease and pest management practices and options so as to enhance the health and quality bean seed.

POTENTIAL USERS OF THIS MANUAL

This manual is prepared as a guide for small-scale seed producing companies, individual farmers specialising in production of bean seed, Non Governmental Organisations (NGOs), Community Based Organisations (CBOs), extension workers and other service providers assisting seed producing farmer groups. The manual complements previous *Handbook for Small Scale Seed Producers* manuals 1, 2 and 3.

ACKNOWLEDGEMENTS

In preparing this manual we have made substantial use of the published work, information and suggestions from many others and we acknowledge the inputs from several colleagues. We acknowledge especially, the rich experiences we gained from working with the small scale seed producing enterprise groups in Mbale, Sironko and Mayuge in Eastern Uganda on seed health, we also acknowledgement the suggestions made by Dr. Flavia Kabere (seed technologist, Makerere University), Ms Namukwaya Prosscovia (extension specialist) and her colleagues from the Swedish Cooperative Center (SCC-VI) after pre-testing an earlier draft of the manual with end users in the field.

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SEEDLING PESTS

Cutworms: Several species belonging mostly to the genera Agrotis and Spodoptera

DISTRIBUTION

Cutworms are generally cosmopolitan and attack seedlings of many crops in the tropics.

NATURE OF DAMAGE

Attack by cutworms is usually sporadic: they appear to suddenly invade a young field and cut young seedlings at the base, near the ground (Fig. 1). On digging into the soil near the cut plants one may find a dull, plump, hairless brown, charcoal gray, or black larva about 3 cm long. The larva curls up tightly when disturbed.

BIOLOGY

The adults lay eggs, mostly on weeds or other crop plants and sometimes in the soil. Young larvae feed on plants where they hatch; older larvae migrate to cultivated fields. They burrow into the soil or hide underneath clods during the day and emerge at night to attack bean seedlings and other field crops.

Figure 1. Cutworm larva at the base of cut bean seedlings

MANAGEMENT STRATEGIES

Cutworms are minor pests of beans and often do not warrant control efforts beyond digging about 5 cm into the soil where the damage is observed and crushing the culprit. However, in situations where the population is high and damage is threatening, the larvae can be baited with straw mixed with an insecticide such as carbaryl (or other stomach poisons) and molasses and spread within the field.

Figure 2. Severe bean fly damage

Figure 3. Egg laying punctures by bean fly

DISTRIBUTION

The pest is widely distributed throughout Africa and attacks beans, cowpeas, soybean and other leguminous plants.

Severe damage is indicated by wilting and dying of seedlings (Fig. 2). The attack disrupts nutrient transportation, causing the tap root to die. The plant attempts to recover by forming adventitious roots above the damaged area. Young seedlings under stress wilt and die within a short time. Older and more vigorous plants may tolerate the damage but become stunted and will have reduced yield.

The presence of the pest is indicated by small shiny black flies; about 2 mm in length with clear wings that reflect a metallic blue color in sunlight. They lay eggs in the leaf tissue or directly in the stem.

Early signs of attack are egg laying punctures on the primary leaves (Fig. 3) which tend to be concentrated around the leaf base. Eggs hatch into small white maggots (Fig. 4) which migrate down the stem to the root zone

Figure 4. Small white maggots or brown or black puparia may be found beneath the stem or root epidermis.

Figure 5. Black pupae on damaged root.

where they pupate into brown or black puparia (Fig. 5). Conditions that favor infestation and damage:

Bean flies are especially active following the peak of the rainy season.

Bean fly damage is aggravated by environmental stresses such as infertile soils, drought or moisture stress, the presence of soil borne diseases and other causes.

Repeated planting of beans in the same plot, which leads to pest population build up, also worsens bean fly damage.

Alternate wild leguminous plants and crops, such as cowpeas, soybean and mung beans as well as volunteer bean plants, are other sources of infestation.

MANAGEMENT STRATEGIES

Bean stem maggot populations tend to peak late in the season: Sowing beans early in the season will hence help to avoid high maggot populations.

Chemical seed dressing with systemic insecticides such as Endosulfan, Acephate, etc. before planting will protect young seedlings, which are the most susceptible, from attack.

Formulations such as "Murtano" combine insecticides and fungicides to protect against bean stem maggots and root rot pathogens.

Growing beans in more healthy and fertile soils (for example through the use of farmyard manure and others), to improve tolerance to infestations.

Use resistant varieties such as EXL 55, G11746, G22501 and other resistant varieties, where available.

Mulching with materials such as rice straw enhances adventitious root formation and recovery tolerance to damage.

DISTRIBUTION

Ootheca species are widely distributed in Africa and attack beans, cowpeas, other leguminous crops as well as okra and other members of the hibiscus family.

BIOLOGY AND NATURE OF DAMAGE

Early sign of trouble is the presence of large swarms of foliage beetles on young beans in the field. This often follows the early rains. They feed voraciously (Fig. 6) and may cause total defoliation of the crop.

The presence of young seedlings of the host plant (beans) appears to stimulate adult emergence of the beetles from hibernation in the soil. Little emergence occurs in the absence of bean or other host plants.

The above ground damage is caused by the adult beetles (Fig. 7) but larvae cause damage below ground.

Larval feeding on roots causes patches of yellowed plants (Fig. 8) in the field. Such plant are stunted, dry up prematurely and may bear empty pods (Fig. 9).

Figure 6. Defoliation from bean foliage beetle

Figure 7. Adult beetles

Figure 8. Yellowed plants from larval feeding on roots

Figure 9. BFB larvae on roots

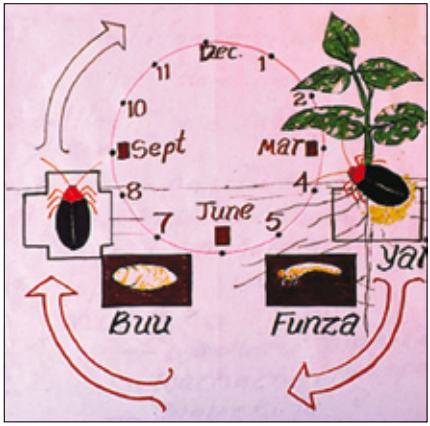

Figure 10. Bean foliage beetle cycle (Tanzania)

In northern Tanzania, the adult beetles appear in the field in mid-March and egg laying starts from about this time till mid-April. Large larvae are seen on roots in May. Pupae are formed in about July and early adults may be observed, often in protective soil cases, in August (Fig 10). Large populations of up to 150 bean foliage beetle/m^2 are usually found in the soil after harvest. They continue in this dormant state until the next rains and cropping season begins.

CONDITIONS THAT FAVOR INFESTATION AND DAMAGE

Continuous planting of beans on the same field without rotation is a key factor that promotes bean foliage beetle population build-up.

MANAGEMENT STRATEGIES

- Post harvest tillage exposes the dormant adults in the soil to the heat of the sun and increases mortality.
- Crop rotation with non-hosts (e.g. maize or sunflower) breaks the development cycle and reduces the emerging adult population.

- Delayed sowing of beans also helps to avoid susceptible stages of the crop coinciding with peaks in the pest population cycle.
- Application of botanical pesticides such as neem (*Azadirachta indica*) seed extracts deter infestation and reduces the damage.
- Where applicable various combinations of these strategies will help control the foliage beetle problem even further.

FLOWER PESTS

Flower and Pollen Beetles: Several species of *Mylabris* and *Coryna*

Common names: Blister beetle, "CMR" beetle, Pollen beetle, Flower beetle

BIOLOGY AND NATURE OF DAMAGE

Flower and pollen beetles that attack beans are large (1.5 to 3 cm long) and are often brightly colored with red or yellow spots on black wing cases. They feed on petals and pollen of flowers and a large infestation can reduce pod setting and yield drastically. Eggs are laid in the soil and the early instar larvae feed on grasshopper eggs; high populations may follow high grasshopper populations. The adults may exude a yellowish fluid that can irritate or cause blisters to the skin.

MANAGEMENT STRATEGIES

Insecticides are not known to be effective against the adult pollen beetles and the more susceptible immature forms do not appear on crops. On small fields hand picking with a pair of tongs may be more practical.

Figure 11. Mylabris sp.

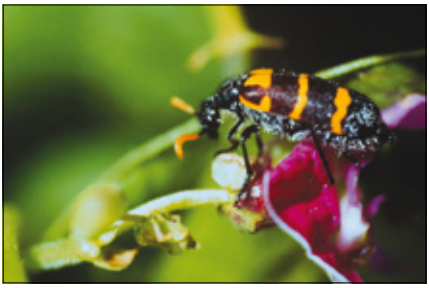

Figure 12. Coryna sp.

POD AND SEED FEEDERS

Pod Borers: *Helicoverpa (=Heliothis) amigera*

Common names: African bollworm, Tomato pinworm

DISTRIBUTION

The bollworm is cosmopolitan, widely distributed and causes damage to beans and several other horticultural crops in the tropics and subtropics. Major host plants include cotton, sorghum, tomato, cowpea and soybean.

The older larvae feed from outside and characteristically leave part of the body exposed. The feeding hole is usually clean and circular with fecal frass usually deposited away from the hole (Fig. 13).

Mature larvae are about 4 cm long and vary in color between yellowish-green, green, brown and black. But ,they all have a characteristic marking of pale and dark bands on each side of the body.

NATURE OF DAMAGE

The young larvae feed within flower buds, flowers and pods. Damaged flowers abort and do not set pods. Larval damage also

Figure13. Bollworm feeding holes

Figure14. Wilting pods

results in several partially eaten seeds that reduce the quality of yield. One larva may damage several pods and cause them to wilt (Fig. 14). The pods may have shriveled or half eaten seeds or bear no seeds at all.

Conditions that favor infestation and attack: Because the bollworm develops on many alternate hosts, it can switch easily and sporadically attack a new bean crop grown in the neighborhood of another host.

MANAGEMENT STRATEGIES

- Avoid relay cropping of beans into established alternate hosts such as tomatoes, cotton, okra, etc.
- Encourage beneficial plant habitats that support natural enemies such as parasites and predators. The presence of predatory ants also reduces pest populations as they feed on small larvae and pupae.
- Botanical products, such as extracts of neem seed kernel, Tephrosia or tobacco leaves, chili, garlic, and others may be applied as foliar sprays to control bollworms.

Figure15. Adult legume pod borer

Figure16. Larvae feeding between a pod and stem

Figure17. Larvae feeding between two pods

Common names: Legume pod borer, Spotted pod borer

DISTRIBUTION

The legume pod borer is widely distributed across the tropics and attacks several leguminous crops.

BIOLOGY AND NATURE OF DAMAGE

Adults have distinctive white bands on brown forewings and are often seen in the field with wings spread and resting on a leaf (Fig. 15). Eggs are laid in small clusters of 10 to 15 on leaves, buds and flowers.

Larvae prefer concealment when feeding. They characteristically attack pods at points of contact between a pod and a leaf or stem (Fig. 16) or a pod and a pod (Fig. 17) and form webs to attach the parts at the points of contact for protection against natural enemies.

A full grown larva has a pale body lined by rows of conspicuous black spots on its dorsal surface (Fig. 18).

The larvae feed from inside flower buds, flowers and pods and often plug the entry hole with fecal frass

(Fig. 19) to protect themselves against natural enemies.

CONDITIONS THAT FAVOUR INFESTATION AND ATTACK

The legume pod borer develops on many alternate hosts and can switch easily from one to the other and sporadically attack a new bean crop grown in the neighborhood of another host.

MANAGEMENT STRATEGIES

Chemical control is difficult because larvae live within flower buds or pods or in well-protected webs. Systemic pesticides such as monocrotophos may accomplish more control than contact insecticides. It is best to scout for the pest and initiate control at the early stages of infestation. Using botanical pesticides such as extracts of: neem seed kernel, Tephrosia or tobacco leaf, chili, garlic, and other treatments may repel the egg laying adults and inhibit feeding by early instars.

Figure18. Fully grown larva

Figure19. Larvae feeding from within pods

Common pod bugs: Clavigralla (*Acantomyia*), *C. tomentosicollis, C. schadabi, C. elegata, C. hystricodes, Riptortus* (*Riptortus dentipes*), Giant coreid bug (*Anoplocnemis curvipes* and *A. madagascriensis*) and green stink bug (*Nezara viridula*)

DISTRIBUTION

Pod bugs are widely distributed throughout Africa. They attack beans, other leguminous crops and trees, okra as well as most horticultural crops. *A. madagascariensis,* however, appears to be restricted to Madagascar.

BIOLOGY AND NATURE OF DAMAGE

The nature of damage caused by pod sucking bugs is similar: They pierce the pod walls and suck the developing seeds. This leaves tiny depressions or dimples (Fig. 20) on the pod wall. The seed rots or shrivels (Fig. 21) and loses viability. The whole pod may shrivel. In addition, *Anoplocnemis* spp. sometimes sucks the sap out of young shoots, causing them to

Figure 20. Depression on pod wall

Figure 21. Rotting seed loses viability

Figure 22. Spiny brown bug: Clavigralla (Acanthomyia), C. schadabi, C. elegata, C. hystricodes.

Figure 23. Giant coreid bug: female Anoplocnemis curvipes and A. madagascriensis

Figure 24. A pair of mating green stink bugs

wilt. *Nezara viridula* may transmit yeast spot fungus to developing seeds.

DESCRIPTION OF THE COMMON POD SUCKING BUGS

Clavigralla tomentosicollis adults are stout, furry and about 10 mm long and brown (Fig. 22). *C. schadabi* and *C. elongata* are narrower, grey and have a pair of elongated spines on the "shoulders"; *C. hystricodes* is black and has a shorter body.

Anoplocnemis spp. are big, about 3 cm and males (Fig. 23) have a large spine on the hind legs. The females lay dark-grey eggs in chains of up to 10 on beans, but in some cases on leguminous trees. The adults are strong fliers and escape to nearby trees when disturbed.

Nezara viridula or the green stink bug (Fig. 24) is green and emits a disgusting smell when alarmed. The female lays 30-60 barrel shaped eggs in clusters on the underside of leaves. First instar nymphs stay together. Later instars disperse to feed.

MANAGEMENT STRATEGIES

Use of pesticide sprays, such as monocrotophos, endosulfan, cypermethrin have been found effective but they need to be applied against the early instar nymphs. Botanical pesticides such as neem seed kernel extract and other concoctions such as fermented cow urine may also repel the adults and nymphs.

Common name: Black bean aphid (*A. fabae*), Cowpea aphid (*A. craccivora*)

DISTRIBUTION

The black bean aphid is the main aphid pest of beans and causes direct damage wherever the crop is grown in Africa. The cowpea aphid may also colonize bean plants especially in low altitudes.

BIOLOGY AND NATURE OF DAMAGE

Initial colonization is by the migratory winged forms which produce dark, somewhat rounded, wingless nymphs. The nymphs are female and reproduce without mating. Winged forms develop when the colony becomes overcrowded or when the food quality deteriorates so as to search for favorable food sources. Many species of aphids are also vectors of virus diseases, such as the bean common mosaic virus. The direct damage caused by aphid colonies may not be as economically important as their ability to transmit the bean common mosaic virus. In this respect several aphid species that do not colonize bean plants but are frequently found on the crop are suspected vectors of the disease.

Colonies form especially around the stems, growing points and leaves (Fig. 25a) but may eventually cover the whole plant. They feed by sucking sap: young plants may desiccate and die; older plants may become stunted and bear distorted leaves (Fig. 25b) and pods.

Figure 25a. Black bean aphid colony

Figure 25b. Leaf distortion

CONDITIONS THAT FAVOR INFESTATION AND ATTACK

Aphid infestations are usually more important in dry conditions. In humid weather, large aphid colonies can be wiped out by fungi that attack insects.

MANAGEMENT STRATEGIES

A combination of natural enemies, including green lacewings (Chrysopidae), various lady beetles (Fig. 26), the minute pirate bug, syrphid flies, and parasitic wasps, are the main natural enemies that keep aphids in check in the field. Certain insecticides have been found effective against aphid colonies but they may also eliminate the natural enemies, aggravating the problem.

Figure 26. A ladybird beetle feeding on an aphid colony

Common name: Whitefly

DISTRIBUTION

This pest is cosmopolitan and occurs in nearly all bean growing ecologies in Africa. They have many hosts, including sweetpotato, and various horticultural crops.

DAMAGE

Both nymphs and adults suck sap from leaves, causing them to become mottled, with light yellowish spots on the upper surface. Whitefly populations may build up in large colonies on the underside of leaves (Fig. 27) and swarm in small white clouds when disturbed. The adults may transmit the cowpea mild mottle virus in beans.

Figure 27. Whitefly colonies on undersides of leaves

CONDITIONS THAT FAVOUR INFESTATION AND ATTACK

Whiteflies have a wide host range that includes many crops and weeds. They tend to breed all year, moving from one host to another as plants are harvested or dry up.

Low levels of whiteflies do not cause much damage and do not warrant control interventions. They can become a problem in

commercial snap bean production environments, where persistent use of pesticides diminishes the natural enemy population allowing whitefly populations to multiply rapidly and develop resistance to the natural enemies.

MANAGEMENT STRATEGIES

Management of heavy whitefly infestations is very difficult. Whiteflies are not well controlled with any available insecticides. However, if you choose to use insecticides, insecticidal soaps or oils such as neem oil, may reduce but not eliminate whitefly populations.

STORAGE PESTS

Bean Bruchids
Common Bean Weevil: *Acanthoscelides obtectus*
Mexican Bean Weevil: *Zabrotes subfasciatus*

Common names: Bean bruchids, Bean weevils

DISTRIBUTION

Bean bruchids are widely distributed in Africa. Two species: *Zabrotes subfasciatus* [Mexican bean weevil (MBW)] and *Acanthoscelides obtectus* [Common bean weevil (CBW)] are known. CBW is more common in high altitude or cool environments, while MBW prevails in warmer environments. In eastern Africa CBW is more frequently encountered. The larvae of both weevils can stay undetected in the seed until the adult emerges. They can be seed borne and spread by seed movement.

LIFE HISTORY

The life history of the two species is similar but important differences exist. The larvae of both species bore into bean seeds to feed and develop, leaving them perforated with holes (Figs. 28, 29). Such seeds lose viability and are unfit for planting or human consumption.

Figure 28. Seed damaged by Acanthoscelides obtecus

Figure 29. Seed damaged by Zabrotes subfaciatus

CONDITIONS THAT PREDISPOSE HARVEST TO ATTACK

- Storage under poor, unhygienic conditions such as stores already infested with bruchids
- Poorly dried beans

MANAGEMENT STRATEGIES

- Early harvests before splits appear in pods to avoid field infestation by CBW
- Drying seeds thoroughly before storage
- Tumbling of seeds in a sack or rolling of seeds in a drum crushes eggs and stops new larvae from penetrating the seed
- Use of MBW resistant varieties reduces infestation from this species
- Boil used storage sacks in hot water and dry in the sun before reuse
- Inspect stored seeds for signs of infestation and take action to stop its development.

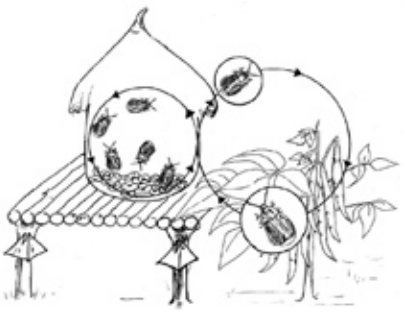

Figure 30. Common bean weevil infestation starts in the field and multiplies in storage. Translucent eggs are placed in pods in the field or among the seeds in stores.

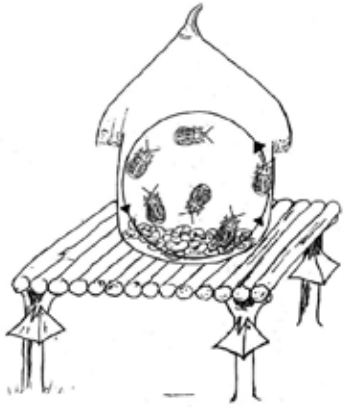

Figure 31. Mexican bean weevil infestation normally starts and multiplies in storage. White eggs are glued to the seeds and the shells remain after hatching.

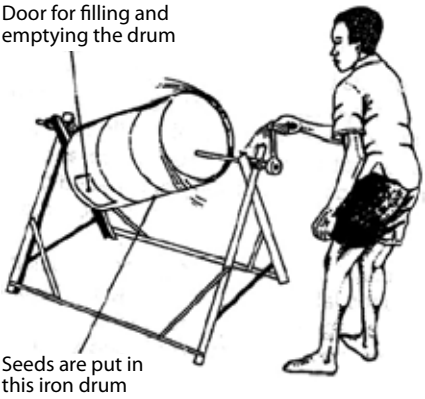

Figure 32. Coat seeds with vegetable oils or neem seed oil at the rate of 5ml/kg of seed. Commercial pesticides such as Malathion or Actellic dust may also be used to disinfest and protect in storage. This is more suitable for seeds intended for planting.

Figure 33. Good storage hygiene: clean the store thoroughly and burn all trash. Spray store with insecticide to disinfest before storage of new beans. Do not mix the new harvest with the old.

SOLARIZATION

Spreading seeds in the sun under plastic covers allows the build up of high temperatures that kill the pests within. Note: This method is unsuitable for seeds intended for planting.

DISEASES AFFECTING LEAVES AND PODS: LEAF SPOTS, LEAF BLIGHTS AND DISCOLORING DISEASES

Halo blight

Angular leaf spot

Anthracnose

DISTRIBUTION

The disease is widespread throughout Africa's bean growing regions, and is favoured by warm to high temperatures and high humidity.

SYMPTOMS

Symptoms first appear as water-soaked spots on the underside of leaves. The leaf spots enlarge and merge to form large brown irregular lesions surrounded by a narrow yellow zone (Fig. 34).

Spots may begin to coalesce, and the yellowing of leaves becomes more general (Fig. 35). The stem may rot at the first node where cotyledons were attached and cause the plant to break.

Pods have sunken circular spots which are water-soaked initially (Fig. 36) but later dry, with a reddish brown narrow border (Fig. 37). Under wet conditions, yellow slimy bacterial exudates ooze out of the lesions and form a crust.

Pods may shrivel and infected (Fig. 38) seed may rot.

Figure 34. Lesions on leaves

Figure 35. Generalized yellowing of leaves

Figure 36. Sunken circular spots on pods

Figure 37. Spots on pods later dry and develop a reddish brown narrow border

Bacteria also invades seed (Fig. 39) and may remain dormant until germination. Even a trace of infected seed when planted can initiate severe infection of whole fields.

SOURCES OF INFECTION

The major source of infection is seed.

Other sources of infection include infected dry bean debris or residue on the soil surface, and infected volunteer plants may be another source. The disease is spread by water splash, wind-blown rain, overhead irrigation, insects and contaminated equipment and clothing.

PREVENTIVE METHODS OF DISEASE MANAGEMENT

- Use of disease free seed
- Chemical seed dressing with Copper Sulphate (Micronized, Basicop 53WP, Blue stone), Copper hydroxide (Kocide 4.5LF) and Streptomycin.
- Crop rotation: not planting beans on infected plots for about three years to eliminate the threat of infection

- Deep plough infested debris to ensure destruction of pathogen
- Suspension of field operations when leaves are wet to reduce the spread of infection
- Plant resistant varieties where available, e.g., ABCP-8, USDK-CBB-15 (GP-244, PI 639867), OAC Rex (OAC 95-4), BAC-6, etc.

CURATIVE METHODS OF DISEASE MANAGEMENT

Spray the crop with chemicals such as Micronized, Basicop 53WP, Kocide 4.5LF and Streptomycin including spot application to infected young plants before infestation spreads.

Figure 38. Pods may shrivel and infected seed may rot

Figure 39. Bacteria-infected seed

DISTRIBUTION

The disease is widespread but more prevalent in mid-to high altitude areas. It is favoured by cool temperatures (16-20°C) and moist, cloudy conditions. It multiplies rapidly in the presence of dew. It is not common in regions or seasons with high temperatures.

The most characteristic symptoms of halo blight occur on the bean leaves (Fig. 40).

SYMPTOMS

Symptoms first appear as small water-soaked pinprick spots on the undersides of leaves. The tissues surrounding the spots gradually become yellow green (Fig. 41) resembling a halo, thus the name halo blight.

Infected branches and petioles bear greasy spots which develop a reddish discolouration. The stem may rot at the first node where cotyledons were attached and cause the plant to break. The spots soon turn reddish brown (Fig. 42).

Figure 40. Halo bight on bean leaves

Figure 41. Area around spots turns yellow green

Figure 42. Spots turn reddish brown

Figure 43. Infected pods exhibit water-soaked lesions

Figure 44. Seed may become shrivelled and discolored or rotten

Infected pods exhibit water-soaked lesions which also develop a reddish discolouration (Fig. 43). Under humid conditions, whitish to yellow bacterial exudates appear on the lesions.

Seed may become shrivelled and discoloured or rotten (Fig. 44). But sometimes no visible symptoms may be seen at all.

SOURCES OF INFECTION

Major sources of infection are infected seed and plant debris.

The disease is spread by water splash, windblown rain and contact among plants due to movement of equipment and/or workers, especially when the foliage is wet.

DISEASE MANAGEMENT STRATEGIES

Prevention of infection may be through a combination of the following strategies:

- Crop rotation with a non-host crop for at least for 2-3 years
- Deep ploughing to bury and destroy the pathogen infected debris
- Use of clean seed

- Planting of resistant varieties where available, e.g., Redkote, Almonga, GLP 92 (pinto)
- Avoiding movement of workers in the field when wet
- Removal of all infected seedlings from the field immediately when sighted
- Suppression by spraying bean crops with registered copper based fungicides such as Kocide 4.5LF

DISTRIBUTION

Angular leaf spot is a serious disease of beans that is widely distributed in Africa. Infection and disease development are favoured by humid conditions and moderate temperatures (20-25°C).

SYMPTOMS

The disease may affect all parts of the bean plant above the ground (Fig. 45). Symptoms are more prominent during the late flowering and early pod formation stages. The disease forms round lesions which usually appear as brown spots with a tan or silvery centre.

The spots are initially confined to tissue between major veins, giving it an angular appearance (Fig. 46). On some varieties a yellow halo may surround the lesions and eventually the entire leaf becomes yellow before aborting prematurely.

Lesions can be observed on the underside of the leaf and appear slightly paler than those on the upper leaf surface (Figs. 47a, 47b). Lesions on stems and petioles appear elongated, and dark brown.

Figure 45. Angular leaf spot affecting all above-ground parts of the plant

Figure 46. Spots initially confined to tissue between veins

Figure 47a. Lesions as seen on upper leaf surface

Figure 47b. Lesions as seen on underside of leaf

Figure 48. Pod lesions

Figure 49. Shrivelled or discoloured seeds

Lesions on pods are sunken irregular to circular black spots with reddish-brown centres and may be similar to those caused by anthracnose (Fig. 48).

Infected pods may bear poorly developed or shrivelled or discoloured seeds (Fig. 49).

SOURCES OF INFECTION

The main sources of infection are plant debris or residue and infected volunteer plants. The disease is spread by contaminated equipment and clothing, splashes of water and windblown rain.

DISEASE MANAGEMENT STRATEGIES

The disease can be managed by a combination of the following strategies:

- Crop rotation with a non host crop e.g., maize for at least 2 years
- Removal or deep ploughing of crop debris or residues
- Seed dressing with suitable fungicides such as Mancozeb, Molybdenum (Mo) sprays, Benzimidazole, Thiabendozole, Trifloxystrobin and Azoxystrobin
- Avoiding movement in the bean fields when the plants are wet
- Planting resistant cultivars where available e.g., AND 277, AND 279 and CAL 143 (in Malawi, South Africa, Tanzania, and Zambia) but these are susceptible in Uganda. Resistant varieties for Uganda include: Mex 54, BAT 332 and G 5686.
- Growing of bean variety mixtures including resistant ones to reduce the spread of infection

DISTRIBUTION

Anthracnose is widespread, common and one of the most important diseases of bean worldwide. It is especially common in regions with frequent rainfall and more destructive under cool to moderate temperatures with high relative humidity.

SYMPTOMS

The disease affects any part of the plant, depending upon time of infection and source of inocula. The initial symptoms of anthracnose appear as a dark brown to black lesion along the veins on the underside of the leaves (Fig. 51). Leaf petioles and even stems may also show this symptom. Sunken cankers also occur on the developing hypocotyls.

The most striking symptoms of bean anthracnose appear on pods (Figs. 51, 52, 53). Pod lesions are typically sunken and are encircled by a slightly raised black ring surrounded by a reddish border (Fig. 53). Under severe infection, young pods may shrivel and dry prematurely.

Figure 50. Bean field affected by Anthracnose disease

Figure 51. Anthracnose lesions on bean stem, pods and underside of bean leaf

Figure 52. Bean anthracnose on pods

The fungus may penetrate through the pod causing discoloration and distortion of the seed (Fig. 54). The fungus may also penetrate the seed coat and become firmly established within the seed. Such infected seed, when planted, serve as the source of infection to the succeeding crop.

SOURCES OF INFECTION

The main sources of Infection are through infected seeds and crop debris.

The disease is spread by rain splash, wind-blown rain and movement of insects, animals and man, especially when plant foliage is moist.

PREVENTIVE METHODS OF DISEASE MANAGEMENT

A combination of the following may help reduce infection and spread of the disease:

- Best control may be achieved by using disease free seed
- Crop rotation with non-hosts (such as cereals) for at least 2 years

Figure 53. Coalesced anthracnose lesions on bean pod

Figure 54. Bean anthracnose on seeds

- Removal or burial of plant debris from fields soon after harvest
- Planting resistant varieties where available, e.g., G 2333, NAT 002, NAT 003 and AB 136
- Dressing seeds with Thiram, Ziram, Arsan, Cerasan to help control infection in the seed coat
- Field activities such as cultivation or pesticide applications restricted when the leaves are wet from rain or dew
- Overhead irrigation discouraged to avoid spread of infection
- Cleaning of seed storage facilities to avoid contamination

CURATIVE METHODS OF DISEASE MANAGEMENT

- Spraying the crop with protectant fungicides or systemic fungicides e.g., Kocide

DISTRIBUTION

The disease occurs widely throughout Africa, particularly under cool and humid conditions.

SYMPTOMS

Symptoms appear first on leaves as large dark grey to black spots. Later the infected area becomes zonate with concentric rings around the spot containing black pycnidia (Figs. 55, 56).

Figure 55. First appearance as large, dark grey to black spots

Figure 56. Concentric rings around areas of infection

A blackening of nodes is characteristic of infection on stems (Fig. 57); it can girdle the stem and kill the plant. Under severe infection, extensive blight and premature leaf drop may occur (Fig. 58).

Figure 57. Severe infection

Figure 58. Bean field severely affected by Ascochyta leaf spot

Flower infection can lead to end rot of pods and cause extensive cankers (Fig. 59). Pod infection often results in seed infection which can be transmitted to the next crop.

SOURCES OF INFECTION

The major sources of infection are infected seed and crop debris. The disease is spread by rain splash and contaminated equipment and clothing.

DISEASE MANAGEMENT STRATEGIES

- Crop rotation with cereals
- Deep ploughing of infected plant debris or residue
- Planting of pathogen /disease-free seed
- Wide spacing to improve aeration and reduce disease development
- Mulching the crop to reduce water splash and spread of inoculum
- Seed dressing with fungicides such as Zeneb, Benomyl, Dithane M 45, or Mancozeb

Figure 59. Pod rot and extensive cankers

DISTRIBUTION

Web blight is sporadic and generally of minor importance in Africa. It occurs mainly in humid lowland tropical regions characterised by high to moderate temperatures. It is caused by the aerial forms of the fungus that causes Rhizoctonia root rot. It is a major bean disease in hot and humid parts of Ethiopia, Madagascar and D.R. Congo.

SYMPTOMS

The general characteristic symptom is that the leaves appear to have been scalded by hot water and may appear grey-greenish to dark brown (Fig. 60).

Small brown necrotic, water-soaked spots first appear on primary leaves. Under favourable conditions the spots expand rapidly and irregularly. Finally the spots cover the whole leaf and make the plant appear burnt (Figs. 61, 62).

The necrotic leaf tissue becomes covered with brown sclerotia and light-brown hyphae which form a web of mould over the plant and lead to defoliation.

Figure 60. Leaves appearing as if scalded, grey-greenish to dark brown

Figure 61. Bean plants appearing burnt due to Web blight

Figure 62. Leaves appearing burnt due to Web blight

Young pod infection appears as light brown, irregular-shaped lesions, which may coalesce and kill the pod. Lesions on older pods are dark brown, circular, lightly zonate and sunken with a dark border. The pod is usually not killed unless the peduncle is destroyed.

SOURCES OF INFECTION

The major sources of infection are crop debris and infected soil.

Web blight has a host range of over 200 species including, beans, tomatoes, cucumber, cabbage, water melon as well as foliage and fruit of uncultivated plants and weeds.

The disease is spread by wind and rain, running water and movement of animals, man or agricultural implements through the field.

DISEASE MANAGEMENT STRATEGIES

- Crop rotation with non-host crops such as tobacco, maize, or grass
- Deep ploughing of infected crop debris and residue
- Planting pathogen or disease free seed
- Wide spacing to maximise air circulation and microclimate conditions that inhibit disease development
- Mulching, where possible, to avoid rain splash and spread of inoculum onto other plants
- Spraying with chemicals such as Maneb, Carbendazim, Benomyl, and Captafol

ABNORMAL OUTGROWTHS ON LEAVES AND PODS

Powdery mildew

Bean rust

White mold

DISTRIBUTION

This disease is sparsely distributed in Africa and is of minor importance. It's mainly favoured by warm temperatures (20-24°C), low humidity and shade.

SYMPTOMS

Powdery mildew can be confused with Floury leaf spot caused by *Mycovellosiella phaseoli*, however, white mould is confined to the upper surface of the leaf unlike floury leaf spot where mould is confined to the lower surface. Symptoms first appear on the upper leaf surface as small, circular, white powdery mould (Figs. 63, 64). The area under the mould becomes dark brown (Fig. 65) and subsequently the white mould may cover the entire upper surface of the leaf.

Figure 63. Small circular moldy spots on upper leaf surface

Figure 64. White mould covering upper leaf surface

The plant may become stunted, malformed, yellow and leaves may fall prematurely. Pods may also become stunted, malformed or killed. Seeds get infected through pod infection and may carry the infection to the next crop if planted.

SOURCES OF INFECTION

The major source of infection is contaminated seed and infected plant debris. The disease is spread by wind, rain and insects.

PREVENTIVE METHODS OF DISEASE MANAGEMENT

- Crop rotation with non-hosts such as, maize and other cereals
- Deep ploughing of residue from diseased plants after harvest
- Use of resistant varieties where available, e.g., ESAL 686
- Use of clean, disease free seed
- Wide spacing of plants to increase aeration

CURATIVE METHODS OF DISEASE MANAGEMENT

- Spraying the crop with sulphur, lime-sulphur, Dinocap, Benomyl, Triforine (SAPROL) etc.

Figure 65. Later stage of infection

DISTRIBUTION

This disease is widespread in eastern Africa in mid- to high-altitude areas with cool to moderate temperature and high relative humidity.

SYMPTOMS

Initial symptoms are round, white spots of mould on the lower surface of leaves. The spots coalesce, become irregularly shaped and powdery (Fig. 66).

On the upper leaf surface the symptoms appear as yellow or green and brown spots which seldom contain mould (Figs. 67, 68). Severe infections may cause premature defoliation. Chlorosis occurs on the upper leaf surface corresponding to lower leaf lesion.

SOURCES OF INFECTION

The major source of infection is contaminated seed.

DISEASE MANAGEMENT STRATEGIES

- Seed dressing with fungicides, e.g. Benomyl or Thiophanate
- Timely application of the same fungicides to the crop
- Planting clean disease free seed

Figure 66. Beans plants showing initial symptoms of Floury leaf spot

Figure 67. Symptoms of Floury leaf spot on upper leaf surface

Figure 68. Symptoms of Floury leaf spot on lower leaf surface

DISTRIBUTION

Widespread but only seasonally important under cool, moist conditions at intermediate altitudes.

SYMPTOMS

The disease attacks old plant tissue such as flowers, cotyledons, pods, seeds, and leaves or injured plant tissue. Symptoms appear initially as greyish-green water-soaked lesions, followed by a white/cotton-like mould growth, accompanied by a watery soft rot on the affected plant part (Figs. 69, 70). Black sclerotia form in and on infected tissue. The infected tissue then becomes dry and light coloured, appearing as if bleached. Wilting may be observed within the plant canopy. Seeds are damaged through pod infection (Fig. 71).

SOURCES OF INFECTION

The major sources of infection are through infected soil, infected or contaminated seed, and infected plant debris/residue.

Alternate hosts include sugar beet, tomato, cauliflower, lettuce, as well as grasses.

Figure 69. Bean pod and stem damaged by White mold

Figure 70. Symptoms of White mold on bean pod

The disease is spread through furrow irrigation and use of irrigation runoff water.

PREVENTIVE METHODS OF DISEASE MANAGEMENT

- Burying infected crop and other plant debris/residues
- Planting tolerant or resistant varieties e.g., USPT-WM-1
- Wide spacing of plants to increase aeration
- Mulching to avoid contact of pods with the soil

CURATIVE METHODS OF DISEASE MANAGEMENT

- Post harvest flooding to suffocate the pathogen
- Timely application of fungicides such as, Benomyl, Dicloran, or PCNB
- Exposing diseased plant debris to the sun to desiccate and kill sclerotia

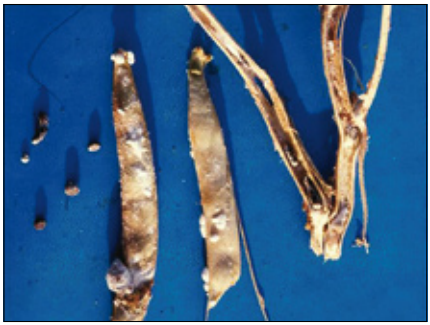

Figure 71. Mature pods and bean stem killed by White mold

DISTRIBUTION

Rust occurs wherever beans are grown. It is favoured by cool to moderate temperatures with moist conditions that result in prolonged periods of free water on the leaf surface for more than 10 hours. Plants infected during the early stages suffer more yield losses. Any factor that delays plant maturity, such as late planting, herbicide damage, excess nitrogen or hail damage, may increase the potential for significant yield loss when a rust epidemic occurs.

SYMPTOMS

Rust can be distinguished from other leaf spots. The spores from the leaf spots rub off onto your fingers, while blights do not.

These leaf spots enlarge to form reddish brown or rust coloured pustules (Figs. 72, 73, 74) and give a rusty appearance to anything they contact.

Severe infection may cause leaves to turn brown, curl upwards, dry, and abort prematurely.

Green pods, and occasionally stems and branches, also may

Figure 72. Leaf rust, upper leaf surface

Figure 73. Leaf rust, lower leaf surface

Figure 74. Spots become reddish brown or rust coloured

become infected and develop typical rust pustules (Fig. 75). Pod set, pod fill and seed size can be reduced if early infection is severe.

A severely damaged bean field (Fig. 76) looks as if has been scorched.

SOURCES OF INFECTION

Major sources of infection are infected bean debris and infected volunteer plants. The disease is mainly spread by wind.

PREVENTIVE METHODS OF DISEASE MANAGEMENT

- Practicing a 2-3 year rotation with non-hosts crops like cereals
- Practicing deep ploughing of infected plant debris
- Removal of potential sources of rust spores e.g., alternate hosts and volunteer plants
- Planting during the recommended periods to reduce late-season exposure to high levels of the pathogen
- Planting rust-resistant varieties such as ABCP-8, BelMiNeb-RMR-8, -9, -10, -11, -12 and -13

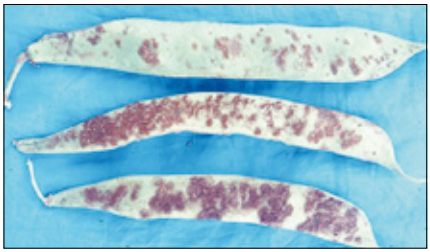

Figure 75. Infected pods

Figure 76. Severely damaged field

- Monitoring plants frequently during flowering and early pod development for initial rust signs, then applying chemicals such as those listed below

CURATIVE METHODS OF DISEASE MANAGEMENT

- Timely use of fungicides such as Chlorothalonil and Maneb formulations

MALFORMATION AND DISTORTION OF LEAVES AND PODS

Bean Common Mosaic Virus (BCMV), Bean Common Mosaic Necrosis Virus Disease (BCMNV)

DISTRIBUTION

These two are the most important viral diseases affecting beans in Africa.

SYMPTOMS

The typical symptoms of both BCMV (Fig. 77) and BCMNV (Fig. 78) are a light green or yellow and dark green mosaic pattern on leaves (Fig. 79) usually accompanied by puckering, distortion and rolling of the leaves. Other symptoms seen on susceptible hosts include mottling, curling and malformation of leaves, as well as general stunting of the plant (Fig. 80).

Severe infection may cause leaf and flower distortions, blistering, stunting, and small pods. Plants infected early in the growing season or grown from infected seed may suffer a delay in maturity and have fewer pods and fewer seeds per pod than healthy plants.

Figure 77. BCMV infection

Figure 78. BCMNV infection

Figure 79. Mosaic pattern on leaves

Figure 80. General stunting of plant

BCMNV (Fig. 81) causes the black root disease in susceptible varieties which occurs as systemic necrosis appearing first on young trifoliate leaves as diffuse reddish-brown areas with reddish-brown to black veins. Stems, pods, seeds and roots may be darkened. Later, apical wilting, die-back and necrosis occur (Fig. 82).

SOURCES OF INFECTION

The major source of infection is infected seed. Other legumes and weed hosts serve as the main inocula. Infection is spread by several species of migrant aphids.

DISEASE MANAGEMENT STRATEGIES

- Planting resistant varieties is the best control measure for BCMV. Examples include OAC Rex (OAC 95-4), BelMiNeb-RMR-8, -9, -10, -11, -12, -13, etc.
- Minimizing the planting of susceptible varieties in areas known to have BCMNV
- Planting clean disease free seeds
- Planting early in the season to help escape the high aphid population period
- Destroying other legumes and weed hosts before planting and during life period of the bean crop

Figure 81. Black root disease from BCMNV

Figure 82. Apical wilting, die-back and necrosis

DISEASES THAT AFFECT THE ROOTS

Bean Root Rots

DISTRIBUTION

Root rot is caused by a complex of several different soil-borne fungi (*Pythium spp, Fusarium solani f. sp. phaseoli, Rhizoctonia solani, Sclerotium rolfsii* and *Macrophomina phaseolina*). Bean root rots are widespread in Africa. They are very common in bean crops that are under stress, i.e., low soil fertility, high humidity, warm to high temperatures, high or low soil moisture, compacted soils, drought, acid soils or soils fertilized with ammonium fertilizers. They are very common especially in over cultivated soils.

SYMPTOMS

Symptoms vary depending on causative organisms and on environmental conditions. However, root rots should be suspected whenever leaves turn yellow or drop off. In general plants wilt and die, plants may become stunted or pods are malformed with under-sized seeds.

Figure 83. Above ground symptoms of beans root rots

Figure 84. Below ground symptoms of bean root rots

PYTHIUM ROOT ROT: *PYTHIUM SPP.*

Pythium root rot causes seedling and post-emergence damping-off. Symptoms appear as elongated water-soaked areas on hypocotyls and roots at 1–3 weeks after emergence and extend several centimetres above or below the soil level (Fig. 85).

Lesions become dry and turn brown with a slightly sunken surface. The fungus also attacks lateral roots causing plant wilt and death. The pathogen can extensively prune roots (Fig. 86), and destroy much of the hypocotyls and main root system.

Pods in contact with moist soil may also become infected and exhibit a watery soft rot and mass of white fungal mycelia.

See page 58 for sources of infection and disease management strategies.

Figure 85. Pythium root rot

Figure 86. Damage to main root system

FUSARIUM ROOT ROT: *FUSARIUM SOLANI F. SP. PHASEOLI*

Symptoms initially appear as narrow, longitudinal reddish brown lesions or streaks on the hypocotyl and primary root 1–2 weeks after seedling emergence. As infection progresses, the lesions coalesce, become brown and extend up to the soil surface (Fig. 87).

Lesions may be accompanied by longitudinal fissures or cracks. The primary and lateral roots frequently are killed and detached. Death of primary roots results in the lower stem becoming hollow.

See page 58 for sources of infection and disease management strategies.

Figure 87. Lesions on roots

Figure 88. Adventitious roots formed in response to Fusarium or Rhizoctonia root rot damage

RHIZOCTONIA ROOT ROT: *RHIZOCTONIA SOLANI*

Initial symptoms on the hypocotyls and tap roots are dark circular to oblong sunken cankers delimited by brown margins (Fig. 89). Later the cankers enlarge and become red, rough, dry and pithy. The cankers girdle the stem resulting in retarded plant growth (Fig. 90). Minute brown sclerotia may develop on or in the cankers.

Lesions also can develop on pods in contact with the moist soil surface, causing pod rotting and seed discoloration.

See page 58 for sources of infection and disease management strategies.

Figure 89. Rhizoctonia root rot

Figure 90. Cankers girdling stems

SCLEROTIUM ROOT ROT: *SCLEROTIUM ROLFSII*

Symptoms initially appear on the stems or hypocotyl just below the soil line as grey water-soaked lesions, which later become dark-brown and extend downward to the tap-root, leading to wilting. Foliage symptoms consist of leaf yellowing and defoliation in the upper plant branches, followed by sudden wilt.

An abundant fan of silky white mould (Fig. 91) and large, round sclerotia (which are at first white but gradually become dark) and soil are attached to the stem base. Pods which touch the soil may become infected and rot. Seeds are contaminated through pod infection (Fig. 92).

See page 58 for sources of infection and disease management strategies.

Figure 91. Sclerotium root rot

Figure 92. Pods which touch soil may become infected

SOURCES OF INFECTION FOR BEAN ROOT ROTS

The main source of infection for bean root rots is infected soil. Other sources of infection include plant debris and infected or contaminated seed.

The disease is spread by irrigation water, wind-blown soil particles and farm tools and machinery.

DISEASE MANAGEMENT STRATEGIES FOR BEAN ROOT ROTS

Disease management for Pythium, Fusarium, Rhizoctonia and Sclerotium root rots

A combination of the following preventive measures may be used:

- Seed and soil treatments e.g. *Pythium* species can be managed with Apron, Ridomil, or Maxim. *Rhizoctonia solani* can be managed with Chloroneb, Topsin, Maxim and Terraclor or PCNB. Initial infection by *Fusarium* can be delayed, but not prevented, by soil fumigation or treatment with Terracoat, Terraclor Super X, or Maxim. *Sclerotium* root rot may be managed with Terraclor 75WP (PCNB).
- Planting resistant varieties e.g., NABE13 (RWR1946), NABE14 (RWR2075), RWR719, MLB-49-89A, SCAM-80-CM/15, G2333 (Umubano), G865 (Vuninkingi), Flor de Mayo.
- Application of farm yard manure or other soil amendments such as Green manure or inorganic fertiliser to improve soil fertility (do not over fertilize with nitrogen).
- Planting in raised beds or ridges will facilitate rapid plant growth.
- Hilling up soil around the stem before flowering may stimulate development of adventitious roots for *Rhizoctonia* and *Fusarium* infected plant.
- Deep ploughing of infected plant material during land preparation. Allow the previous crop to be well decomposed prior to planting.
- Practicing a 2–3 year rotation with non-host crops such as cereals.

DISTRIBUTION

This root rot disease is found throughout the tropics and subtropics and has a wide host range. It is most damaging in areas of unreliable rainfall and high temperature.

SYMPTOMS

The disease infects the cotyledons and the hypocotyls at soil level producing black, sunken cankers which have a sharp margin and concentric rings. The plant's growing tip may be killed and the stem may break at the cankers. It also causes damping-off and seedling blight.

Young plants have black wounds and stems have ash-like wounds on diseased bean stems (Fig. 93), thus the name "ashy stem blight". Black charcoal-like flakes occur on old grey wounds on stems, pods and seeds.

Infection on older plants may cause stunting, leaf chlorosis, wilting, premature defoliation, rotting of the stem and roots and plant death (Fig. 94). The infection is more pronounced on one side of the plant. Damaged seeds shrivel and lose colour.

Figure 93. Ashy stem blight

Figure 94. Leaf wilting and defoliation

PREVENTIVE METHODS OF DISEASE MANAGEMENT

A combination of the following measures may be used:

- Planting clean disease-free seed
- Dressing seeds with fungicides such as Thiram, Murtano, etc.
- Roguing and burning infected bean plants
- Planting resistant varieties if available, e.g., BAT 477 or XAN 176
- Practicing a 2–3 year rotation with non-hosts crops like cereals

CURATIVE METHODS OF DISEASE MANAGEMENT

- Fumigating the soil with Chloropicrin, methyl bromide, etc.
- Flooding of the soil if possible to suffocate the pathogen

DISTRIBUTION

The disease is widespread but unevenly distributed in Africa. It is favoured by relatively low humidity and high temperatures during drought periods as well as when plants are wounded.

SYMPTOMS

Thes are easily confused with those of Fusarium root rot. However, in seedlings, infection causes stunting, wilting and death. The fungus can also cause water-soaked lesions on pods.

The pathogen penetrates the vascular tissue of the root and hypocotyl producing a reddish discoloration throughout the root, stem, petioles and peduncles. Infection causes yellowing of lower leaves and may progress to the upper leaves, causing premature defoliation.

SOURCES OF INFECTION

Infected soil is the most common source of infection. Other sources include infected plant residues, debris and contaminated seed.

Spread of disease is through irrigation, wind-blown soil particles and contaminated farm equipment.

Figure 95. Fusarium wilt

Figure 96. Fusarium wilt

DISEASE MANAGEMENT STRATEGIES

- Crop rotation with non-host crops, e.g., maize or sorghum
- Deep ploughing of infected bean residues and plant debris
- Use of organic amendments such as farmyard manure, green manure, etc. to improve the soil fertility
- Plant resistant varieties if available, e.g., G 2333, Jamapa, Rio Tibagi, UI 911
- Seed dressing with fungicides, e.g., Cerasan, Semisan, Thiram, Benomyl

Figure 97. Reddish discoloration throughout the root, stem, petioles and peduncles, characteristic of Fusarium wilt

ENVIRONMENTAL FRIENDLY PESTICIDES FOR PEST AND DISEASE CONTROL

A combination of control strategies known as Integrated Pest and Disease Management (IPDM) is likely to offer a more holistic approach to the biotic constraints on a crop than single control strategies. Such a package usually aims at minimising the use of pesticides while harvesting the complimentary benefits of especially the cultural practices. Pesticides are known to have some adverse effects to the environment and human life if not well utilised. Nevertheless their use could be minimised and made affordable by developing cost-effective spray schedules and integrating their use with host resistance and cultural practices. Farmers who have access to and can afford pesticides should adhere recommended application rates as well as monitor pests populations so that pesticides are applied only when required. Biopesticides unlike chemical pesticides are biochemical pesticides that are naturally occurring substances that control pests by non-toxic mechanisms. They include various naturally-occurring materials, including fungal or plant extracts.

BIOPESTICIDE CONCOCTIONS MOST COMMONLY PREPARED BY FARMERS FOR PEST CONTROL

- Neem seed kernel extract/suspension (NSKE 5%)
- Tephrosia leaf extract
- Fermented cattle dung and urine
- Aqueous extracts of tobacco leaves, chilies, garlic, etc. in various combinations
- Nuclear polyhedrosis virus (NPV)

COMMERCIALLY AVAILABLE BIOPESTICIDES

- Neem extract (powders and oils)
- *Bacillus thuringiensis* (BT)

PREPARATION OF NEEM SEED KERNEL EXTRACT/SUSPENSION

1. Soak neem seed kernels (5 kg) in a minimum amount of water overnight.
2. Pound the neem seed kernels in a mortar and keep the paste in a fine cloth bag for 2 hr. Place the bag of NSK paste in a container filled with about 10 liters of water, and agitate periodically for 30 min to extract as much of the active ingredients as possible.
3. Squeeze the bag thoroughly or as dry as possible, remove and filter the resulting white suspension and add soap flakes (100 g) to the suspension.
4. Dilute the suspension with water by 10 times (e.g. 500 ml in 5 liters) and spray to cover the crop.

Use only ripe neem fruit and separate the seed from the pulp and dry under shade before storing in gunny bags. Drying in the open sunlight may diminish the quality of the active ingredient. Store in a well aerated environment. Storage in confined areas or in tight plastic bags may induce fungal growth which will degrade the active ingredient and effectiveness of the product. Large quantities of neem kernels should be treated with clay dust (in 1:10 ratio).

Neem extracts can prevent egg laying and disrupt feeding and development of many pests.

PREPARATION OF CHILI-GARLIC EXTRACT

1. Grind green chilies (3 kg) after removing the stalk (pedicel) and then soak the resulting paste overnight in water (10 liters).
2. Grind garlic (0.5 kg) and then soak overnight in 250 ml of kerosene.
3. Dissolve soap (75 g) in one liter of water.
4. Mix all three solutions and let stand for 4 hours, then filter through a muslin or other porous cloth and dilute with water to make 80 liters.

This will be enough to spray an acre of beans.

PREPARATION OF CATTLE-DUNG AND URINE EXTRACT

1. Dilute cattle dung (5 kg) into water (5 liters) and add cow urine (5 liters).
2. Ferment the resulting solution for 4 days in an enclosed container in a shaded area and then add lime (100 g) to neutralize the toxic phenols and acids released.
3. Dilute the resulting solution in 80 liters of water . This is sufficient to spray an acre of beans.

This solution deters female moths laying eggs of leaf feeding larvae (*H. armigera* and *S. litura*) and protects against some diseases.

PREPARATION OF NPV

1. Collect larvae from fields that have died from NPV (400 *H. armigera*, or 200 *S. litura*). Seek advice from local NARS or trained NGO if unsure how to do this.
2. Grind the larvae to a suspension and filter through fine cloth.
3. Dilute in 100 liters of water and then add Robin Blue dye (100 g) to protect from UV light in the field.
4. Spray crop with the NPV solution during early evening.

The virus of one pest species does not affect other species. It may take several days (2 to 5) before the larvae in the field are killed by the spraying of virus. However, within 10 days all larvae will have become affected.

BIO-PESTICIDES FOR DISEASE MANAGEMENT

Neemark (*Azadirachta indica*) 0.5% is effective against *Sclerotium* root rot.

Formulations of *Trichoderma viride* and *Pseudomonas fluorescens* are effective against a wide range of root and stem rots caused by *Rhizoctonia, Sclerotium* and *Pythium* root rots These bio-pesticides should be mixed at the rate of 4 g per kg of seed as a paste or slurry.

Bacillus subtilis strain GBO3 (Kodiak), and *Rhizobium tropici* strain UMR 1899 have been used as seed treatments to control *Fusarium* root rot, *Fusarium* wilt and *Rhizoctonia* root rots.

The major treatment recommended for bean seed is seed dressing with pesticides, however, the best means of ensuring production of clean healthy seed is to ensure a healthy crop though proper management of bean diseases as well as practicing proper post-harvest management strategies.

Monitoring the crop to identify early symptoms of pests and diseases is a good management strategy to avert problems and ensure a better seed yield in terms of quality and quantity.

GLOSSARY OF TERMS

Bacterial exudates: Fluid containing bacteria.

Cankers: A localized diseased or necrotic area on a plant part, usually caused by fungi or bacteria.

Chlorosis: Yellowing of plant tissue.

Fungus (plural fungi): Comprised of heterotrophic organisms characterized by a chitinous cell wall, and in the majority of species, filamentous growth as multicellular hyphae forming a mycelium; some fungal species also grow as single cells.

Halo: A circular band of light colored tissue around a leaf spot or a lesion appearing like the circular band of light around the sun or moon.

Hypha (plural hyphae): A fungal thread: the unit structure of fungi.

Mycelium (plural mycelia): Mass of hyphae constituting the body of a fungus.

Inoculum (plural inocula): An infectious agent or substance of either a virus, fungi, bacteria or toxin that multiplies itself within the plant causing a particular disease on a host plant.

Instar: A stage in the larval development of an insect, between two molts.

Lesion: An abnormal tissue found on or in an organism, usually damaged by disease.

Necrosis: The death of living cells or tissues.

Pycnidium (plural pycinidia): Asexual flask-shaped fruiting body lined inside with spores.

Sclerotium (plural sclerotia): A resting body composed of a hard mass of hyphae and a darkened hard layer, which may remain dormant for long periods under favourable conditions.

Sporadic: A pest or diseases occurring occasionally, singly, or in irregular or random instances.

Other titles in this series:

Handbook One:	*Producing Bean Seed*, by Soniia David
Handbook Two:	*Business Skills for Small-Scale Seed Producers*, by Soniia David and Beth Oliver
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