Handbook of Pigeonpea Diseases

Information Bulletin no. 42

International Crops Research Institute for the Semi-Arid Tropics

Abstract

Reddy, M.V., Raju, T.N., Sharma, S.B., Nene, Y.L, and McDonald, D. 1993. Handbook of pigeonpea diseases. (In En. Summaries in En., Fr.) Information Bulletin no. 42. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 64 pp. ISBN 92-9066-277-8. Order code IBE 042.

Pigeonpea (*Cajanus cajan* (L.) Millsp.) is one of the most important grain legume components of subsistence farming systems in the semi-arid tropics. Many fungi, viruses, nematodes, bacteria, and mycoplasma-like organisms attack pigeonpea, but only a few of these are important constraints to pigeonpea production. This bulletin provides information on the causal agents, distribution, economic importance, symptoms, epidemiology, and management of major diseases of pigeonpea. The text is supplemented with color photographs of disease symptoms and a diagnostic key is included to facilitate identification. Information is provided on control measures that include the use of resistant varieties, cultural practices, and chemicals. Supporting literature on the major diseases is listed.

Résumé

Manuel des maladies du pois d'Angole. Le pois d'Angole [*Cajanus cajan* (L.) Millsp.] est l'une des légumineuses à grain les plus importantes des systèmes d'agriculture de subsistance au sein des régions tropicales semi-arides. Plusieurs champignons, virus, nématodes, bactéries et organismes de type mycoplasmique attaquent le pois d'Angole, mais seul quelques-uns constituent des contraintes majeures à la production du pois d'Angole. Ce bulletin offre des informations sur les agents causaux, la répartition, l'importance économique, les symptômes, l'épidémiologie ainsi que la lutte contre les maladies importantes de cette culture. Le texte est accompagné de photographies en couleur des symptômes de maladies et une clé diagnostique permet leur identification. Des informations sont fournies sur les moyens de lutte y compris l'emploi de variétés résistantes, de pratiques culturales et de produits chimiques. Une bibliographie de la documentation de base sur les maladies importantes du pois d'Angole est prévue.

Cover: Collar rot (*Sclerotium rolfsii*) kills seedlings at the primary leaf stage.

Handbook of Pigeonpea Diseases

M.V. Reddy, T.N. Raju, S.B. Sharma, Y.L. Nene, and D. McDonald

ICRISAT

Information Bulletin no. 42

International Crops Research Institute
for the Semi-Arid Tropics
Patancheru, Andhra Pradesh 502 324, India

1993

Contents

Introduction

Pigeonpea (*Cajanus cajan* (L) Millsp.) is an important grain legume crop of rainfed agriculture in the semi-arid tropics. The Indian sub-continent, eastern Africa, and central America, in that order, are the world's three main pigeonpea-producing regions. Pigeonpea is cultivated in more than 25 tropical and sub-tropical countries, either as a sole crop or intermixed with such cereals as sorghum [*Sorghum bicolor* (L.) Moench], pearl millet [*Pennisetum glaucum* (L.) R. Br.], or maize (*Zea mays* L.), or with legumes, e.g., groundnut (*Arachis hypogaea* L.). Being a legume, pigeonpea enriches the soil through symbiotic nitrogen fixation. A short-day plant with a deep root system, pigeonpea tolerates drought, but is highly sensitive to waterlogging. The crop has many uses; fresh pigeon peas are eaten as a vegetable, the grain is cooked and eaten as *dhal* (dry split cotyledons), the wood is used as fuel, and the leaves and husks provide livestock feed.

The crop is cultivated on marginal lands by resource-poor farmers, who commonly grow traditional medium- and long-duration (5-11 months) landraces. Short-duration pigeonpeas (3-4 months) suitable for multiple cropping have recently been developed. Traditionally, the use of such inputs as fertilizers, weeding, irrigation, and pesticides are minimal, so present yield levels are low (average = 700 kg ha^{-1}). Greater attention is now being given to managing the crop because it is in high demand at remunerative prices. There is also a trend away from traditional intercropping to sole cropping.

Diseases are major biological constraints to production and more than 60 pathogens including fungi, bacteria, viruses, mycoplasma, and nematodes can infect pigeonpeas. Fortunately, only a few of them cause economic losses. Of these, sterility mosaic and witches' broom are region-specific, whereas others such as fusarium wilt are widespread across regions.

This handbook has been prepared to assist in field diagnosis of pigeonpea diseases. The diseases are grouped according to the kind of damage they cause. In addition to symptomatology, information on distribution, economic importance, epidemiology, and control measures is included to make the handbook more useful to growers, scientists, and extension practitioners.

Diseases that Kill the Plant

This Section deals with several diseases caused by fungi, one caused by a bacterium, and one abiotic stress—waterlogging—that commonly result in death of plants.

Collar Rot

Sclerotium rolfsii Saccardo

Distribution. India, Pakistan, Puerto Rico, Sri Lanka, Trinidad and Tobago, USA, and Venezuela.

Economic importance. A minor disease that can cause severe losses when undecomposed organic matter is left on the surface of seedbeds. Pigeonpea following cereal crops such as sorghum is likely to be infected if stubbles have not been cleared from the field.

Epidemiology. Temperatures of about 30°C and soil moisture at sowing predispose seedlings to infection. In India the disease is more of a problem in early-sown (June) than in later-sown crops.

Symptoms. A seedling disease that usually appears within a month of sowing, when patches of dead seedlings at the primary leaf stage are seen, scattered over the field (Fig. 1). The seedlings may turn slightly chlorotic before they die. The confirmatory symptom is rotting in the collar region that is covered with white mycelial growth; this differentiates collar rot from other seedling diseases caused by *Fusarium, Rhizoctonia,* or *Pythium.* Seedlings affected by collar rot can be uprooted easily, but the lower part of their root usually remains in soil. Sometimes white or brown sclerotial bodies of the fungus can be found attached to the collar region of a dead seedling or in the soil around it.

1

Phytophthora Blight

Phytophthora drechsleri Tucker **f. sp. *cajani***
(Mahendra Pal, Grewal & Sarbhoy) Kannaiyan, Ribeiro, Erwin & Nene

Distribution. Dominican Republic, India, Kenya, Panama, and Puerto Rico.

Economic importance. A devastating disease that kills young (1-7 week-old) plants, leaving large gaps in plant stands. Yield losses are usually higher in short-duration pigeonpeas than in medium- and long-duration types.

Epidemiology. The disease is soilborne. The fungus survives as chlamydospores, oospores, and dormant mycelium in soil and on infected plant debris. Cloudy weather and drizzling rain with temperatures around 25°C favor infection, that requires continuous leaf wetness for 8 hours to occur. Pigeonpeas gradually develop tolerance to the disease as they grow older and are not infected after they are 60 days old. The disease is more common on Alfisols than on Vertisols, and appears first in low-lying areas of fields where water temporarily stagnates. The thick canopy of short-duration types occasioned by close spacing (30 x 10 cm), and their higher genetic susceptibility, seem to encourage blight build-up. Warm and humid weather following infection results in rapid disease development and plant death. Wind and rain help to disseminate zoospores and by damaging the plant, facilitate infection. *Cajanus scarabaeoides* var. *scarabaeoides,* a wild relative of pigeonpea is also a host of the blight pathogen.

Symptoms. Phytophthora blight resembles damping off disease in that it causes seedlings to die suddenly (Fig. 2). Infected plants have water-soaked lesions on their leaves (Fig. 3) and brown to black, slightly sunken lesions on their stems and petioles (Fig. 4). Infected


2


3


4

leaves lose turgidity, and become desiccated. Lesions girdle the affected main stems or branches which break at this point and the foliage above the lesion dries up (Fig. 5). When conditions favor the pathogen, it is common for many plants to die (Fig. 6). Pigeonpea plants that are infected by blight, but not killed often produce large galls on their stems especially at the edges of the lesions (Fig. 7). The pathogen infects the foliage and stems but not the root system.

Fusarium Wilt

Fusarium udum Butler

Distribution. Bangladesh, Ghana, Grenada, India, Indonesia, Kenya, Malawi, Mauritius, Myanmar (Burma), Nepal, Nevis, Tanzania, Thailand, Trinidad and Tobago, Uganda, and Venezuela.

Economic importance. The annual losses due to wilt have been estimated at US $ 71 million in India and US $ 5 million in eastern Africa.

Epidemiology. The disease is seed and soilborne. The fungus can survive on infected plant debris in the soil for about 3 years. Wilt symptoms usually appear when plants are flowering and podding, but sometimes occur earlier when plants are 1-2 months old. Disease incidence is more severe on Vertisols than on Alfisols. Early sowing, good weed management, and good crop growth encourage wilt development. Long- and medium-duration types suffer more from wilt than short-duration types. Ratooning predisposes the plant to wilt. Pigeonpeas intercropped with sorghum are less attacked by wilt than sole-cropped plants.


5


6

Symptoms. Patches of dead plants in the field when the crop is flowering or podding are the first indication of wilt (Fig. 8). The most characteristic symptom is a purple band extending upwards from the base of the main stem (Fig. 9). This band is more easily seen in pigeonpeas with green stems than in those with colored stems. Partial wilting of the plant is a definite indication of fusarium wilt, and distinguishes this disease from termite damage, drought, and phytophthora blight that all kill the whole plant. Partial wilting is associated with lateral root infection, while total wilt is due to tap root infection.

The other characteristic symptom of wilt is browning of the stem tissue in the region of the purple band (Fig. 10) and browning or blackening of the xylem, visible when the main stem or primary branches are split open (Fig. 11). The intensity of browning or blackening decreases from the base to the tip of the plant. Sometimes, branches (especially lower ones) dry, even if there is no band on the main stem. These branches have die-back symptoms with a purple band extending from tip downwards, and intensive internal xylem blackening (Fig. 12). When young plants (1-2 months old) die from wilt, they may not show the purple band symptom, but have obvious internal browning and blackening. Plants infected by *F. udum* also exhibit a series of leaf symptoms before they die, including loss of leaf turgidity, interveinal clearing, and chlorosis to bright yellow.

8

9

10

11

12

Dry Root Rot

Macrophomina Stem Canker

Rhizoctonia bataticola (Taub.) Butler

Macrophomina phaseolina (Tassi) Goidanich

Distribution. India, Jamaica, Myanmar (Burma), Nepal, Sri Lanka, and Trinidad and Tobago.

Epidemiolgy. A serious problem in late-sown or summer crops and in perennial or ratooned pigeonpeas. The disease also affects short-duration pigeonpeas sown in the rainy season. Hot (30°C and above) and dry weather encourage disease development, that is more prevalent on Vertisols than on Alfisols. Rain after a prolonged dry spell predisposes plants to the disease. Crops are more susceptible in the reproductive stage than in the vegetative stage.

Symptoms. Infected plants suddenly and prematurely dry up (Fig. 13). When such plants are uprooted their roots are rotten and shredded (Fig. 14). The finer roots are mainly affected and have dark, blackend streaks underneath their bark with evident dark sclerotial bodies (Fig. 14). Such roots are brittle and break when touched. Under hot, humid conditions root rotting extends to the base of the stem (Fig. 15). Early symptoms on stems and branches are spindle-shaped lesions (Fig. 16) with light gray centers and brown margins with scattered pycnidial bodies (Fig. 17, x200). The lesions coalesce and cause the branches or whole plants to dry up and die.

13

14

15

16

17

Phoma Stem Canker

Phoma Cajani (Rangel) Khune & Kapoor

Distribution. Brazil and India.

Symptoms. Normally seen at advanced stages of plant growth. Initial symptoms on stems appear as lesions with gray centers and dark brown margins. The lesions contain pycnidia. As the disease progresses lesions coalesce and girdle the stem, and then develop into large swollen cankers (Fig. 18) leading to the premature death of the plant.

Anthracnose

Colletotrichum cajani Rangel

Colletotrichum graminicola (Ces.) Wilson

Distribution. Brazil, India, Puerto Rico and USA (Hawaii).

Symptoms. A minor stem disease that appears as irregular brown to grayish stem lesions containing dark scattered acervuli (Fig. 19). Severe infection leads to drying and death of infected branches. Minute spots with dark margins and gray centers scattered with acervuli are also common on the leaves and pods of infected plants.

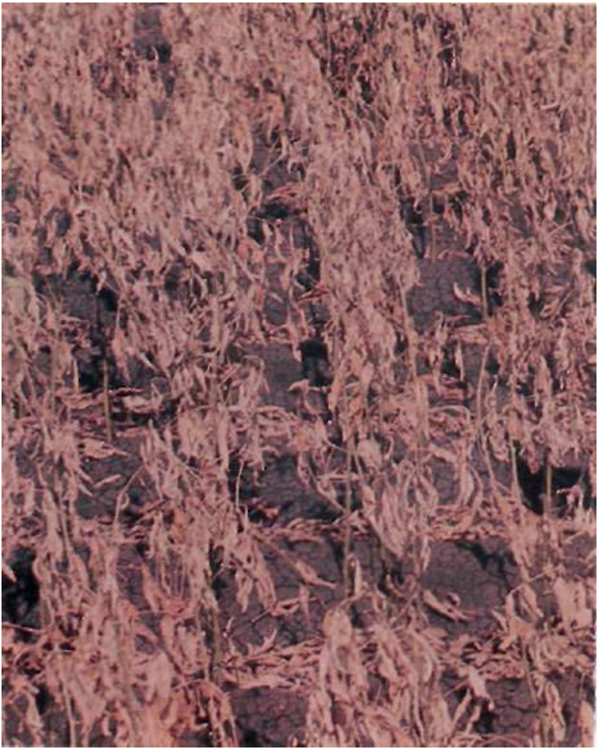
18

19

Waterlogging

Epidemiology. Pigeonpea is highly susceptible to waterlogging, that can result in the sudden death of plants. Waterlogging is most severe when a few days of rain and cloudy weather are followed by sunny days. Pigeonpea suffers less damage from waterlogging in weedy or intercropped fields, than in well weeded sole cropped fields.

Symptoms. Dead plants (Fig. 20) do not show any external stem symptoms and can be easily uprooted. Waterlogged roots are rotten, foul-smelling, and their bark is easy to peel off. It is possible to confuse death due to waterlogging with that due to wilt or phytophthora blight. However, the most characteristic symptom of waterlogging is the presence of brown patches with wavy margins in the collar region, that can be seen when the bark is peeled off (Fig. 21). Reddish-brown discontinuous streaks can be seen in the wood; these differ from wilt streaks which are black and continuous. Death from waterlogging and stem lesions caused by phytophthora blight can sometimes occur simultaneously and in such cases it may be difficult to decide the exact cause of death. In adult plants waterlogging causes sudden death, while phytophthora blight takes time to kill a plant. Adult pigeonpea plants are more susceptible to waterlogging than are seedlings.



20

21

Leaf Spots, Blights, and Defoliating Diseases

This Section brings together diseases that affect the foliage. Some of the diseases may cause severe damage, but they rarely lead to death of plants.

Bacterial Leaf Spot and Stem Canker

Xanthomonas campestris* pv. *cajani
(Kulkarni, Patel & Abhyankar) Dye

Distribution. Australia, India, Myanmar (Burma), Panama, Puerto Rico, and Sudan.

Epidemiology. Warm (25-30°C) and humid weather favors disease development. Disease incidence is generally higher in low-lying waterlogged areas of the field than in well-drained areas. African germplasm is more susceptible to the disease than Indian germplasm. Pigeonpeas with purple stems are less susceptible to stem canker than those with green stems. While leaf infection can occur at all stages of plant growth, stem infection usually occurs in younger plants.

Symptoms. In India the disease usually appears in the rainy season during July and August. It can be seen on the lower leaves of plants that are about 1 month old as small necrotic spots surrounded by bright yellow halos. Later, rough, raised, cankerous lesions appear on the stem (Fig. 22). Leaf spots (Fig. 23) do not usually cause defoliation. Cankers can cause stems to break, but the broken part usually remains attached to the plant (Fig. 22). Stems often break at the point where the primary leaves are attached. Often, the affected plants do not break, and the stem cankers increase in size until they are 15-25 cm long (Fig. 24). In cases of severe infection the affected branches dry.

22

23

24

Powdery Mildew

Oidiopsis taurica (Lev.) Salmon

(Teleomorph: ***Leveillula taurica*** [Lev.] Amaud)

Distribution. Ethiopia, India, Kenya, Malawi, Sri Lanka, Tanzania, Uganda, and Zambia.

Epidemiology. This is a polycyclic disease, i.e., there is an initial infection and secondary spread. Infection is directly proportional to the quantity of inoculum available as conidia. Indian varieties with thin, succulent leaves that are easily colonized by the fungus are more susceptible than those from Kenya that have thicker leaves. The disease develops at temperatures ranging from 20 to 35°C, but 25°C is the optimum. A cool, humid climate is congenial to fungal infection and colonization, but a warm humid climate is good for sporulation and spore dispersal. Sporulation is more frequent on young leaves than on older ones. Plants attacked by sterility mosaic or phyllody support abundant sporulation. Since sterility mosaic and phyllody-infected plants remain green in the field for long periods they provide a continuous source of inoculum. The fungus survives on perennial pigeonpeas and volunteer plants growing in the shade, and on the ratoon growth of harvested stubbles. It also survives as dormant mycelium on infected plant parts, e.g., axillary buds. In India early sowing and irrigation encourage disease establishment.

Symptoms. Infected plants have white powdery fungal growths on all their aerial parts, especially the leaves, flowers, and pods (Fig. **25a).** Severe infections result in heavy defoliation (Fig. **25b).** The disease causes stunting of young plants, followed by the visible symptoms of white powdery growth that appear gradually before the flowering stage. The initial symptoms develop as small chlorotic spots on the upper surface of individual leaves (Fig. 26) and subsequently the corresponding lower surfaces develop white powdery patches (Fig. 27). When the fungus sporulates, this white powdery growth covers the entire lower leaf surface (Fig 28).


25a


25b


26


27


28

Cercospora Leaf Spot

Cercospora cajani Hennings (most prevalent)

Cercospora indica Singh

Cercospora instabilis Rangel

Cercospora thirumalacharii Sharma & Mishra

(Teleomorph: ***Mycovellosiella cajani*** [Henn.] Rangel ex Trotter)

Distribution. Bangladesh, Brazil, Colombia, Dominican Republic, Guatemala, India, Jamaica, Kenya, Malawi, Mauritius, Nepal, Nigeria, Puerto Rico, Sri Lanka, Tanzania, Trinidad and Tobago, Uganda, Venezuela, Zambia, and Zimbabwe.

Economic importance. The disease is a problem in humid regions. Yield losses up to 85% have been reported from eastern Africa, and losses are severe when defoliation occurs before flowering and podding.

Epidemiology. Cool temperatures (25°C) and humid weather favor the disease, which normally appears when plants are flowering and podding. Cyclonic rains in southern and north-eastern peninsular India result in sudden outbreaks of the disease in certain years. The disease is more common in the long-duration and perennial pigeonpeas grown in eastern Africa.

Symptoms. First appear as small circular to irregular necrotic spots or lesions usually on older leaves (Fig. 29). These lesions coalesce causing leaf blight and defoliation. During epidemics lesions appear on young branches and cause their tips to dry and die back. The Indian isolates of the pathogen produce a fluffy mycelial growth on their lesions, while the African isolates produce concentric zonations on their lesions (Fig. 30).

29

30

Alternaria Blight

Alternaria **sp**

Alternaria tenuissima (Kunze ex Persoon) Wiltshire

Alternaria alternata (Fries) Keissler

Distribution. India, Kenya, and Puerto Rico.

Epidemiology. Not a serious problem in rainy-season crops sown at the normal time, but does cause problems in crops sown late (September), or in the postrainy season on the plains of north-eastern India. Seed infection has only been reported from Puerto Rico.

Symptoms. Symptoms develop as small, circular, necrotic spots on leaves (Fig. 31), that develop quickly forming typically concentric rings. The lesions appear on all aerial plant parts including pods. They cause blighting of leaves (Fig. 32), and severe defoliation and drying of infected branches. The fungus sporulates well under warm, humid conditions.

31

32

Phyllosticta Leaf Spot

Phyllosticta cajani Sydow

Distribution. Brazil, India, Jamaica, Puerto Rico, Sri Lanka, and Trinidad and Tobago.

Epidemiology. A problem in warm, humid climates; the disease usually appears in July and persists throughout the cropping season. Serious epidemics can develop during October in the north-eastern plains of India. Mean temperatures ranging from 20 to 30°C with a mean humidity range of 73-80% favor severe outbreaks.

Symptoms. Round, necrotic spots, up to 10 mm in diameter appear on the leaves. These lesions have wavy dark brown margins with gray centers; they contain characteristically concentric rings of pycnidial bodies (Fig. 33). In severe infections desiccation and defoliation occur.

Fusarium Leaf Blight

Fusarium semitectum Berkley & Rav.

Distribution. India and Puerto Rico.

Symptoms. A problem on pigeonpea crops in the north-eastern hills of India, disease symptoms appear as dark brown, circular to elliptical lesions, 2-10 mm in diameter on the leaves. These lesions originate on leaf margins, and coalesce to form dark brown patches. Infected leaves become yellow and dry prematurely. When the weather is humid, white mycelia with abundant conidia appear on the blighted leaves.

33

Rust

Uredo cajani Sydow

Distribution. Bermuda, Colombia, Guatemala, India, Jamaica, Kenya, Nigeria, Puerto Rico, Sierra Leone, Sri Lanka, Tanzania, Trinidad and Tobago, Uganda, and Venezuela.

Epidemiology. Disease severity increases with the onset of flowering. Dense planting and the formation of a closed canopy provide a microclimate favorable for disease development. Light rain, wind, and cloudiness encourage spore release, dispersal, and disease development.

Symptoms. Normally seen as dark brown raised pustules full of uredia on the lower leaf surfaces (Fig. 34). The infected leaves desiccate, and drop off. There is extensive defoliation when infections are severe.

Halo Blight

Pseudomonas syringae **pv.** ***phaseolicola***
(Burkholder) Young, Dye & Wilkie

(syn ***P. phaseolicola)***

Distribution. Australia, Ethiopia, and Zambia

Symptoms. The disease develops on leaves as dark-brown angular necrotic spots 1 mm in diameter surrounded by large chlorotic halos 10 mm in diameter. Under humid conditions, these spots coalesce giving the leaves a blighted appearance. The symptoms are more commonly seen on the soft, young leaves of older and ratooned plants. Persistent rains and cloudy weather result in severe disease development.

34

Botrytis Gray Mold

Botrytis Cinerea Persoon ex Fries

Distribution. Bangladesh, India, Nepal, and Sri Lanka.

Symptoms. Disease symptoms usually appear when plants are flowering, as dark gray fungal growth on the growing tips, flowers, and pods. Infected flowers (Fig. 35) drop, thus reducing pod set. The shed flowers and leaves on the ground are covered with sporulating mycelium of the fungus (Fig. **36**).

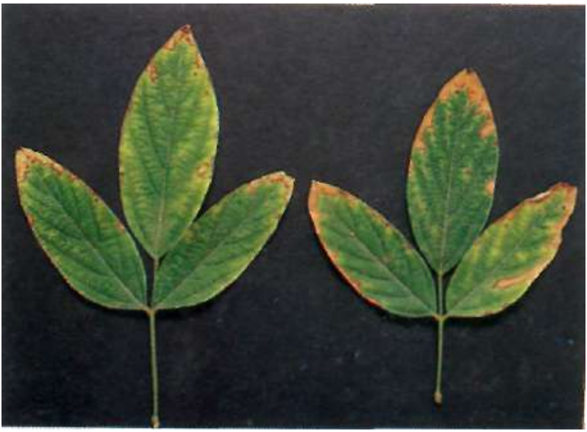
Marginal Leaf Burning

Symptoms. Start with marginal chlorosis and progresses to the "burning" of the margins of leaf laminae (Fig. 37) commonly observed late in the season. The problem is exacerbated by prolonged dry spells. The symptoms first start in lower leaves and progress upwards. They can be distinguished from those of fungal leaf blights by their systematic nature and the absence of chlorotic area between the dried and healthy portions of the laminae that are characteristic of symptoms caused by pathogens.

The reasons for leaf burning are not well understood, but it could be due to soil salinity that results in a gradual accumulation of salts in the leaves.

35

36



37

Mosaics and Sterility

This Section includes some diseases caused by viruses and mycoplasma-like organisms.

Sterility Mosaic

Etiology. Unknown

Vector. Eriophyid mite ***Aceria cajani*** Channabasavanna

Distribution. Bangladesh, India, Myanmar (Burma), Nepal, and Sri Lanka.

Economic importance. A serious problem in Nepal and India where it is estimated to cause annual pigeonpea grain losses worth US $ 282 million.

Epidemiology. A single eriophyid mite vector (Fig. 38, x200) is sufficient to transmit the disease. The mites are very small and can be seen easily under a stereo-binocular (40x) microscope, they can be wind borne up to 2 km from the source of inoculum. Both pathogen and the mite vector are specific to *Cajanus cajan* and its wild relative *C. scarabaeoides* var. *scarabaeoides* that is commonly found on wastelands and field bunds. Perennial (Fig. 39) and volunteer pigeonpeas, and the ratooned growth of harvested plants provide reservoirs of the mite vector and the pathogen. Disease incidence is high when pigeonpeas are inter- or mixed cropped with sorghum or millets. Symptoms are suppressed during the hot summer months but with monsoon rains they reappear on the new growth. Shade and humidity encourage mite multiplication, especially in hot summer weather.

Symptoms. In the field, the disease can be easily identified from a distance as patches of bushy, pale green plants (Fig. 40) without flowers or pods (Fig. 41). The leaves of these plants are small and show a light and dark green mosaic pattern (Fig. 42). The mosaic symp-

38

39

40

41

42


toms initially appear as vein-clearing on young leaves. When infection occurs at 45 days after emergence or later, only some parts of the plant may show disease symptoms, while the remaining parts appear normal (Fig. 43).

Some pigeonpea varieties, e.g., ICP 2376 exhibit ring spot leaf symptoms (green islands surrounded by chlorotic areas), these indicate localized sites of infection of the pathogen (Fig. 44), and such plants produce normal flowers and pods.

Strains of sterility mosaic prevalent in the Indian state of Bihar and in Nepal cause severe internodal shortening of the branches and clustering of leaves. Sometimes these leaves become filiform.

Yellow Mosaic

Mung bean yellow mosaic virus

Vector. White fly ***Bemisia tabaci*** Gennadius

Distribution. India, Jamaica, Nepal, Puerto Rico, and Sri Lanka.

Symptoms. Affected plants are conspicuous in the field, because of the green and golden yellow mosaic mottle symptoms on their leaves (Fig. 45). Sometimes the affected parts of the leaves become necrotic. Diseased plants are usually scattered in the field, and may produce fewer pods than normal, especially when infected early. Off-season and isolated sowings suffer more from the disease than does the main-season crop, because pigeonpea is not a preferred host of the white fly vectors; they only feed on the crop when forced to by the absence of other host plants.

43

44

45

Witches' Broom

Mycoplasma-like organism

Vector. Leaf hopper ***Empoasca*** sp

Distribution. Australia, Bangladesh, Costa Rica, Dominican Republic, El Salvador, Haiti, Jamaica, New Guinea, Panama, Puerto Rico, Taiwan, Trinidad and Tobago, and USA.

Symptoms. Infection results in excessive proliferation and clustering of branches with small pale green leaves (Fig. 46). This gives the plant a 'witches' broom' appearance. Such plants rarely produce flowers and pods. Flowers, if produced appear in clusters with elongated pedicels. The whole or part of the plant may exhibit symptoms, depending on the intensity of the disease.

Phyllody

Mycoplasma-like organism

Vector. Not known.

Distribution. India, Myanmar (Burma), and Thailand.

Symptoms. The disease can only be recognised at flowering. Diseased plants are scattered in the field and can be easily recognized because they are bushy with an axillary proliferation of phylloid flowers (Fig. 47). This disease, like yellow mosaic, is seen more often in off-season sowings than in main-season crops, but its incidence is still low. Phyllody differs from witches' broom, as in the former flowers are converted into leafy structures, while in the latter there are no flowers.


46


47

Bracteomania

Genetic abnormality

Distribution. India

Symptoms. Affected plants are stunted with few branches, they produce solitary simple leaves with obtuse tips and long petioles attached to their stems, twigs, and floral shoots. Axillary flower buds proliferate into abnormal, clustered inflorescences (Fig. 48). The flowers of affected plants are sessile, small, bunchy, and tightly packed, giving the inflorescences a knotted appearance. Such flowers do not produce normal pods.

48

Stunting

This Section covers three kinds of nematode-induced diseases commonly characterized by stunting.

Root-knot

Meloidogyne incognita (Kofoid & White) Chitwood

Meloidogyne javanica (Treub) Chitwood

Meloidogyne arenaria (Neal) Chitwood

Meloidogyne acronea Coetzee

Distribution. Australia, Bangladesh, Brazil, Egypt, India, Kenya, Malawi, Nepal, Puerto Rico, Trinidad and Tobago, Uganda, USA, Zambia, and Zimbabwe.

Economic importance. Eight to 35% yield losses have been reported from the Caribbean, Africa, and southeast Asia.

Epidemiology. *Meloidogyne incognita* and *M. javanica* are the two most widely distributed root-knot nematode species in tropical, subtropical, and warm temperature climates. They have a very wide host range and occur in an extensive range of soil types, but their association with crop damage is reflective of sandy soils or sandy patches within fields. Weed hosts help to maintain high populations of nematodes in fields. The severity of root-knot disease increases in fields with combined infestations of *M. javanica* and *M. incognita.* Infection by these species increases the severity of fusarium wilt infection.

Symptoms. Aerial parts show no characteristic symptoms, but reduced plant vigor (Fig. 49), delayed flowering in a whole or some patches of a field and leaf yellowing are all indicative of nematode infestation. Root galls (knots) are the most characteristic symptom of infection, and can easily be seen with the naked eye (Fig. 50). When the galls are very small, examining roots for the presence of egg sacs is a useful way to confirm nematode infection.


49


50

Pearly Root

Heterodera cajani Koshy

Distribution. Egypt and India.

Economic importance. Yield losses as high as 30% have been reported as a result of infection. An initial population density of three juveniles cm^{-3} of soil can cause 25% reduction in plant biomass and yield.

Epidemiology. The host range of the cyst nematode *Heterodera cajani* is largely confined to species of the Leguminosae, but *Sesamum indicum* (Pedaliaceae) and *Phyllanthus maderaspatensis* (Euphorbiaceae) are non-legume hosts. *Heterodera cajani* is widespread in sandy loam soils in northern India and in black cotton soils in western and southern India. The nematode lives up to 45 cm deep in soil throughout the year. Summer fallowing reduces densities of *H. cajani* by 45% at 0-15 cm but does not affect densities at lower soil depths. Nematode infestation enhances the aggressiveness of *Fusarium udum* infection in wilt-susceptible pigeonpeas.

Symptoms. First noticed as poor and stunted plants evident 30-45 days after sowing (Fig. 51). If the roots of infected plants are carefully examined, many minute, pearl-like, white females of *H. cajani* can be seen attached to them (Fig. 52). These females can be seen with the naked eye, but are more clearly visible through a hand lens (10x). Nematode infestation can delay flowering and pod formation for more than a week.

51

52

Dirty Root

Rotylenchulus reniformis Linford & Oliveira

Distribution. Fiji, India, Jamaica, Puerto Rico, and Trinidad and Tobago.

Economic importance. Infestation severely affects pigeonpea production in Fiji, and is associated with variable crop growth in northern India, and on sandy and red soils (Alfisols) in western and southern India. Damage thresholds range from preplant nematode densities of 1.0 to 4.0 cm^{-3} of soil, depending on the soil type and climatic factors.

Epidemiology. This nematode attacks many crops in 38 subtropical and tropical countries. Its extensive host range includes several fruit, vegetable, legume, oilseed, millet, ornamental, and plantation crops. It can reduce the number of *Rhizobium* nodules a legume plant produces. Although, the wilt pathogen reduces the density of the nematode, wilt-susceptible genotypes die prematurely when the nematode and the fungus are both present in the soil. The nematode can survive in the absence of a host for more than 300 days without losing its infectivity, but summer fallowing reduces *R. reniformis* densities to 70% at 0-15 cm soil depth and 36% at 15-30 cm soil depth.

Symptoms. Infected plants generally grow less vigorously than healthy ones (Fig. 53). Infected plants have smaller root systems than healthy plants. If these plants are uprooted egg masses covered with soil are found on their roots (Fig. 54). Infected roots appear dirty because soil particles adhere to the mucilaginous nematode egg sacs, and are not easily dislodged when the roots are shaken. If these roots are dipped in 0.25% trypan blue and rinsed in water, the nematode egg sacs are selectively colored blue while the roots are not stained. This technique can be used to identify reniform nematode infection without using a microscope.

53

54

Disease Management

Successful disease management requires integration of such practices as growing resistant or moderately resistant varieties, modification of sowing dates to avoid environmental conditions conducive to disease, use of crop hygiene and cultural practices known to reduce disease severity, and application of appropriate fungicides as soil fumigants, seed protectants, and foliar sprays. Specific packages of practices have to be developed for each crop production system and environment, and socio-economic factors need to be considered. It is therefore not possible to prescribe any overall disease management practice but the information provided in Tables 1-4 should be useful in putting together packages for particular situations.

Table 1. Sources of disease resistance.

Disease	Resistant varieties/lines
Fusarium wilt	AL 1, BDN 2, Birsa Arhar 1, DL 82, H 76-11, H 76-44, H 76-51, H 76-65, ICP 8863 (Maruti), ICP 9145, ICPL 267, Mukta, Prabhat, Sharda, TT 5, TT6
Sterility mosaic	Bageshwari, Bahar, DA 11, DA 13, ICPL 86, ICPL 146, ICPL 87051, MA 165, MA 166, PDA 2, PDA 10, Rampur Rahar

Continued

Table 1. *Continued*

Disease	Resistant varieties/lines
Phytophthora blight	Hy 4, ICPL 150, ICPL 288, ICPL 304, KPBR 80-1-4, KPBR 80-2-1 (Field resistant)
Cercospora leaf spot	UC 796/1, UC 2113/1, UC 2515/2, UC 2568/1
Powdery mildew	ICP 9150, ICP 9177
Alternaria blight	DA 2, MA 128-1, MA 128-2, 20-105 (West Bengal)
Dry root rot	ICPLs 86005, 86020, 87105, 91028
Bacterial leaf spot and Stem canker	ICPs 12807, 12848, 12849,12937, 13051, 13116,13148
Phoma stem canker	AL 133, AL 136, ICPL 148, ICPL 84018
Rust	Blanco, Todo Tempo No. 17
Phyllody	BDN 5, ICPL 83057, MRG 66
Halo blight	GW 3, ICPL 362
Phyllosticta leaf spot	EMC, ICPL 161, ICPL 269, ICPL 335, Pusa 33, Pusa 85
Root-knot	ICP 11289, ICP 11299
Dirty root	AGS 522, Basant, GAUT 82-75, GAUT 83-23, GAUT 84-22, ICP 12744, PDM 1

Table 2. Sources of multiple disease resistance.

Diseases	Resistant varieties/lines
Wilt + Phoma stem canker + Phyllody + Halo blight + Phyllosticta leaf spot	ICPL 87, C 11
Wilt + Sterility mosiac + Phytophthora blight	ICPL 83024
Wilt + Sterility mosaic + Powdery mildew	ICP 7867
Wilt + Phytophthora blight + Halo blight	BDN 1
Sterility mosaic + Powdery mildew + Halo blight	Hy 3C, ICP 7035
Wilt + Sterility mosaic	ICP 9174, ICPL 227, ICPL 87119, NPWR 15
Wilt + Halo blight	ICPL 81
Sterility mosaic + Alternaria blight	ICPL 366
Sterility mosaic + Root-knot	ICPL 151 (Jagriti)

Table 3. Cultural practices for disease control.

Disease	Suggested cultural practices
Fusarium wilt	• Select a field with no previous record of wilt for at least 3 years • Select seed from disease-free fields • Grow pigeonpea intercropped or mixed with cereal crops, e.g., sorghum • Rotate pigeonpea with sorghum, tobacco, or castor every 3 years • Uproot wilted plants and use them for fuelwood • Solarize the field in summer to help reduce inoculum
Sterility mosaic	• Select a field well away from perennial or ratoon pigeonpeas • Destroy sources of sterility mosaic inoculum, i.e., perennial or ratooned pigeonpeas • Uproot infected plants at an early stage of disease development and destroy them • Rotate crops to reduce sources of inoculum and mite vectors

Continued

Table 3. *Continued*

Disease	Suggested cultural practices
Phytophthora blight	* Select fields with no previous record of blight * Avoid sowing pigeonpea in fields with low-lying patches that are prone to waterlogging * Prepare raised seedbeds and provide good drainage * Use wide interrow spacing
Witches' broom	* Select fields away from perennial pigeonpeas affected with witches' broom * Pull out and destroy any infected plants to minimize secondary spread of disease * Avoid ratoon cropping
Cercospora leaf spot	* Select fields away from perennial pigeonpeas which are a source of inoculum * Select seed from healthy crops
Powdery mildew	* Select fields away from perennial pigeonpeas affected with the disease which are a source of inoculum * Sow late (after July) in India, to reduce disease incidence
Alternaria blight	* Avoid fields close to perennial pigeonpeas

Continued

Table 3. *Continued*

Disease	Suggested cultural practices
Alternaria blight *(contd.)*	* Select seed from healthy crops * Sow early
Dry root rot	* Select fields with no previous record of dry root rot * Avoid sowing late so that the crop escapes from drought and high temperatures at maturity
Collar rot	* Select fields where cereal crops (such as sorghum) have not been grown during the previous season * Collect cereal stubbles from the field and destroy them before sowing pigeonpeas
Bacterial leaf spot and Stem canker	* Select well-drained fields * Select seed from healthy crops
Phoma stem canker	* Avoid fields with previous records of the disease * Remove infected plants to reduce the build-up of inoculum in the soil
Rust	* Avofd sowing pigeonpea close to bean fields * Rotate crops to reduce the chance of pathogen survival
Yellow mosaic	* Avoid sowing late to reduce disease severity

Continued

Table 3. *Continued*

Disease	Suggested cultural practices
Yellow mosaic *(contd.)*	* Uproot and burn infected plants if the disease appears on isolated plants in the field
Phyllody	* Select fields away from perennial pigeonpeas and sesamum
Anthracnose	* Avoid fields with previous blight records
Root-knot	* Select field with no previous record of nematode infestation
	* Rotate pigeonpea with wheat to reduce nematode populations
	* Solarize soil in summer to reduce nematode populations
Pearly root	* Select fields with no previous record of nematode infestation
	* Rotate crops with sorghum, maize, or pearl millet to reduce nematode populations
	* Solarize soil in summer to reduce nematode populations
Dirty root	* Select fields with no previous record of nematode infestation
	* Rotate crops with rice, maize, or groundnut to reduce nematode populations
	* Solarize soil in summer to reduce nematode populations

Table 4. Chemical control measures.

Disease	Chemical treatment
Fusarium wilt	* Seed dressing with Benlate T® (benlate 50% + thiram 50% mix) @ 3 g kg^{-1} seed
Sterility mosaic	* Seed dressing with 25% Furadan 3 G® or 10% aldicarb @ 3 g kg^{-1} seed
	* Spraying acaricide or insecticides like Kelthane®, Morestan®, metasystox @ 0.1% to control the mite vector in the early stages of plant growth
Phytophthora blight	* Seed dressing with Ridomil MZ® @ 3 g kg^{-1} seed
	* Two foliar sprays of Ridomil MZ® at 15-day intervals starting from 15 days after germination
Witches' broom	* Spray insecticides (e.g., metasystox @ 0.1%) to controJ the leaf hopper
Cercospora leaf spot	* Spray maneb (Indofil M 45®) @ 3 g L^{-1} water
Powdery mildew	* Spray wettable sulfur @ 1 g L^{-1} or triadimefon (Bayletan® 25% EC) @ 0.03%
Alternaria blight	* Spray maneb (Indofil M 45®) @ 3 g L^{-1} water

Continued

Table 4. *Continued*

Disease	Chemical treatment
Collar rat	* Seed dressing with tolclofos-methyl (Rhizolex®), captan, or thiram @ 3 g kg^{-1} seed
Bacterial leaf spot and Stem canker	* Spray antibiotics like Streptocycline® (strepto-mycine and tetracycline) @ 100 µg L^{-1} at 10-day intervals
Rust	* Spray maneb (Indofil M 45®) @ 3 g L^{-1} water
Yellow mosaic	* Spray insecticide (metasystox @ 1 g L^{-1}) to control the white fly
Phyllody	* Spray insecticides such as metasystox to control the vector
Anthracnose	* Spray maneb (Indofil M 45®) @ 3 g L^{-1} water
Halo blight	* Spray antibiotics like Streptocycline® (strepto-mycine and tetracycline) @ 100 µgL^{-1}
Botrytis gray mold	* Spray Ronilan® or Daconil® @ 3 g L^{-1} water
Phyllosticta leaf spot	* Spray maneb (Indofil M 45®) @ 3 g L^{-1} water

Continued

Table 4. *Continued*

Disease	Chemical treatment
Fusarium leaf blight	* Spray Benlate-T® @ 3 g L^{-1} water
Root-knot	* Soil application of chemicals such as aldicarb, carbofuran, fensulfothion, and phorate (2 to 6 kg ha^{-1})
Pearly root	* Same as for root-knot nematode
Dirty root	* Same as for root-knot nematode

Key to the Diagnosis of Major Diseases

1.	Plants die	*See* 2
	Plants do not die	*See* 5
2.	No external restricted lesions on main stem or branches	**Fusarium wilt**
	Collar rot with white mycelial growth	**Collar rot**
	Root rot	**Dry root rot**
	Brown chromatographic type lesions on wood at collar region	**Waterlogging**
	External lesions on main stem and branches without enlarged swellings	*See* 3
	External lesions on main stem and branches with enlarged swellings	*See* 4
3.	Lesions elongated, sunken, without discrete margin and galls on their margins	**Phytophthora blight**
	Lesions localized with discrete marginal acervuli	**Anthracnose**
	Lesions spindle-shaped with gray centers	**Macrophomina stem canker**
4.	Enlarged swellings	**Phoma stem canker**
5.	Lesions localized and cankerous	**Bacterial stem canker**
	Plant growth stunted, without any characteristic symptoms on foliage	*See* 6
	Plant growth stunted with characteristic symptoms on foliage	*See* 7
6.	Swelling (knots) on main and lateral roots	**Root-knot**
	Minute pearl-like white females on roots	**Pearly root**
	Soil particles adhere to roots, difficult to dislodge by shaking	**Dirty root**

7.	Clusters of closed buds in leaf axils	**Bracteomania**
	White powdery fungal growth on foliar parts	**Powdery mildew**
	Dark gray fungal growth on leaves, flowers, and pods	**Botrytis gray mold**
	"Burning" of the margins of leaf laminae	**Marginal leaf burning**
	Necrotic spots on foliage	*See* 8
	Lesions on foliage	*See* 9
	Mosaic, stunting, sterility	*See* 10
8.	Necrotic spots circular to irregular	**Cercospora leaf spot**
	Necrotic spots small, circular, with pycnidia, and wavy margins	**Phyllosticta leaf spot**
	Necrotic spots large, circular to irregular, with zonation	**Alternaria blight**
	Necrotic spots small, with chlorotic halos	**Bacterial leaf spot**
	Necrotic spots small, with chlorotic halo	**Halo blight**
9.	Small, dark-brown, raised pustules	**Rust**
	Large necrotic lesions on leaf margins	**Fusarium leaf blight**
10.	Green and golden mosaic symptoms on leaves	**Yellow mosaic**
	Light and dark green mosaic symptoms on leaves and sterility	**Sterility mosaic**
	Small leaves, axillary proliferation, and sterility	**Witches' Broom**
	Phylloid flowers and sterility	**Phyllody**

Supporting Literature

Ghanekar, A.M., Sheila, V.K., Beniwal, S.P.S., Reddy, M.V., and Nene, Y.L. 1992. Sterility mosaic of pigeonpea. Pages 415-428 *in* Plant diseases of international importance. Diseases of cereals and pulses. vol. 1. (Singh, U.S., Mukhopadhyay, A.N., Kumar, J., and Chaube, H.S., eds.). Englewood Cliffs, New Jersey 07632, USA: Prentice Hall, Inc.

Kannaiyan, J., Nene, Y.L., Reddy, M.V., Ryan, J.G., and Raju, T.N. 1984. Prevalence of pigeonpea diseases and associated crop losses in Asia, Africa, and the Americas. Tropical Pest Management 30:62-71.

Reddy, M.V., Sharma, S.B., and Nene, Y.L. 1990. Pigeonpea: disease management. Pages 303-347 *in* The Pigeonpea (Nene, Y.L, Hall, S.D., and Sheila, V.K., eds.). Wallingford, Oxon OX10 8DE, UK: CAB International.

Reddy, M.V., Raju, T.N., Naik, M.K., Nene, Y.L., and McDonald, D. (In press). Integrated disease management in pigeonpea. *In* Integrated pest management systems in agriculture (Razak, R.L, and Upadhyay, R.K., eds.). Faridabad, India: Directorate of Plant Protection, Quarantine and Storage, Government of India.

Sharma, S.B., Smith, D.H., and McDonald, D. 1992. Nematode constraints of chickpea and pigeonpea in the semi-arid tropics. Plant Disease 76:868-874.

Singh, U.P., and Chauhan, V.B. 1992. Phytophthora blight of pigeonpea. Pages 375-387 *in* Plant diseases of international importance. Diseases of cereals and pulses. vol.1. (Singh, U.S., Mukhopadhyay, A.N., Kumar, J., and Chaube, H.S., eds.). Englewood Cliffs, New Jersey 07632, USA: Prentice Hall, Inc.

Upadhyay, R.S., and Rai, B. 1984. Wilt of pigeonpea. Pages 388-414 *in* Plant diseases of international importance. Diseases of cereals and pulses. vol.1. (Singh, U.S., Mukhopadhyay, A.N., Kumar, J., and Chaube, H.S., eds.). Englewood Cliffs, New Jersey 07632, USA: Prentice Hall, Inc.

Subject Index

About ICRISAT

The semi-arid tropics (SAT) encompasses parts of 48 developing countries including most of India, parts of southeast Asia, a swathe across sub-Saharan Africa, much of southern and eastern Africa, and parts of Latin America. Many of these countries are among the poorest in the world. Approximately one sixth of the world's population lives in the SAT, which is typified by unpredictable weather, limited and erratic rainfall, and nutrient-poor soils.

ICRISAT'S mandate crops are sorghum, pearl millet, finger millet, chickpea, pigeonpea, and groundnut; these six crops are vital to life for the ever-increasing populations of the semi-arid tropics. ICRISAT's mission is to conduct research which can lead to enhanced sustainable production of these crops and to improved management of the limited natural resources of the SAT. ICRISAT communicates information on technologies as they are developed through workshops, networks, training, library services, and publishing.

ICRISAT was established in 1972. It is one of 18 nonprofit, research and training centers funded through the Consultative Group on International Agricultural Research (CGIAR). The CGIAR is an informal association of approximately 50 public and private sector donors: it is co-sponsored by the Food and Agriculture Organization of the United Nations (FAO), the World Bank, and the United Nations Development Programme (UNDP).

International Crops Research Institute for the Semi-Arid Tropics
Patancheru, Andhra Pradesh 502 324, India

ISBN 92-9066-277-8 Order code: IBE 042 93-494