DISEASES AND PESTS OF CENTROSEMA

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Summary

Diseases caused by 38 genera of fungi, one bacterium, one mycoplasma, 13 viruses and six genera of nematodes have been recorded on *Centrosema*. Potential arthropod pests include thrips, aphids, leafhoppers, leaf beetles, caterpillars, podborers, leafrollers, flies and mites. The relative importance of each disease and pest varies among *Centrosema* species and locations.

Rhizoctonia foliar blight is the most important disease of *Centrosema* in tropical Latin America. *C. brasilianum* is the most susceptible species, but significant damage has recently been observed on some accessions of *C. acutifolium*. At least three species of *Rhizoctonia* are implicated, and isolates vary in virulence, making studies of host resistance complicated and time-consuming. Research on methods of screening for resistance to *Rhizoctonia*, on isolate variability, on natural biological control agents, on epidemiology and on the effect of grazing on foliar blight incidence and severity is in progress and is given a very high priority.

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Other diseases are of secondary importance or site-specific. Pseudocercospora leaf spot is a potentially important disease of *C. brasilianum* in savanna ecosystems.

Bacteriosis caused by *Pseudomonas fluorescens* Biotype II has damaged susceptible accessions of *C. acutifolium* at one site in the humid tropics, and is seed-borne. Research on a *Centrosema* mosaic virus, another seed-borne disease, is given high priority. Although it is not yet widespread, CeMV damages *C. macrocarpum*, *C. brasilianum* and several other species. Further work is needed to evaluate the importance of parasitic nematodes.

Leaf-eating insects, principally Chrysomelidae and other Coleoptera, cause significant damage to *Centrosema* across the major ecosystems of Latin America. At present it is not known which insect species are predominant at individual sites, and there is a lack of information specific to *Centrosema* (most arthropod pests have a wide range of hosts). Continued monitoring at major screening sites is essential to identify the major pests, to determine whether true differences exist between sites in the importance of particular pests, to measure the severity of damage and to confirm apparent differences between *Centrosema* species and/or accessions in resistance to particular pests. The ladybird beetle, *Epilachne indica*, is a major pest of *Centrosema* in Malaysia. Research on this problem is a priority.

Introduction

Diseases and insect pests have been recorded on *Centrosema* spp., especially *C. pubescens*, since the early 1900's, but research to evaluate their importance has been lacking. Increased agronomic research and more widespread cultivation have fostered an increased awareness of the potential role of diseases and pests as major constraints to the productivity of Centrosema.

This chapter collates information on diseases and pests of Centrosema, describes their distribution and relative importance, and discusses management of some of them.

Diseases of Centrosema

Diseases caused by 38 genera of fungi, one genus of bacterium, one mycoplasma, 13 viruses and six genera of nematodes have been recorded on Centrosema. The wealth of information from Latin America (Appendix 1), New Guinea and Malaysia (Appendix 2) reflects intensive activity by plant pathologists. The apparent lack of diseases in other countries is partly a reflection of lack of interest or plant pathology skills. Detailed comparisons of pathogen identities and disease severity among regions are therefore of little value except within tropical America. Also, many reports of diseases occur in host lists, Commonwealth Mycological Institute unpublished records, and in personal surveys made by the authors and colleagues. Hence, it is difficult to discuss the relative importance of many of the diseases. Widely occurring and/or more damaging diseases will be discussed in greater depth.

Diseases caused by fungi

Leaf spots caused by Cercospora and related genera. Three species of Cercospora have been recorded across major ecosystems of tropical Latin America (Appendix 1). C. canescens is the most common and widespread being recorded on nine Centrosema species in all ecosystems in more than eight countries. It causes dark brown to black angular leaf lesions with chlorotic halos (Figure 1) which expand causing chlorosis, necrosis and defoliation (Lenné *et al*. 1983). High relative humidity and moderately high temperatures favour infection and disease development. *C. pubescens* may be difoliated but other species are generally less affected (Appendix 1), thus *C. canescens* is not an especially serious disease (Lenné *et al*. 1983; CIAT 1981-85). *C. centrosemae* and *C. cylindrospora* have been recorded on *C. virginianum* in Venezuela and Mexico (Chupp, 1953; Appendix 1), and six other *Cercospora* species have been recorded on *Centrosema* in other regions (Appendix 2).

Pseudocercospora bradburyae (Syn. *Cercospora bradburyae*) is the most widespread leaf spot being recorded on nine *Centrosema* species across major ecosystems of tropical America in more than seven countries (Appendix 1). It is present in other regions (17 countries) on *C. plumieri*, *C. pubescens* and *C. virginianum* (Appendix 2). *P. bradburyae* forms small rounded cream to pale grey leaf spots with dark borders (Figure 2). Coalescense of lesions causes defoliation yet rarely plant death. In North Queensland leaf lesions of *P. bradburyae* together with *Colletotrichum gloeosporioides* can cause severe defoliation in the winter when *C. pubescens* is not growing actively (R. Davis pers. comm.). However, plants recover when growth resumes. In tropical America, *Pseudocercospora* leaf spot sometimes severely damages *C. brasilianum* under humid conditions (CIAT 1985).

Leaf spots and pod anthracnose caused by *Colletotrichum* spp.

Colletotrichum gloeosporioides and *C. truncatum* are common on *Centrosema* spp. in tropical America (Appendix 1). On leaves, rounded to irregular cream-coloured lesions are formed while on pods, similar lesions tend to be ulcer-like, affecting developing seeds (Figure 3); (Lenné et al. 1983). Often, dark fruiting bodies can be seen in these lesions. They occur together in latent infection of pods (Lenné, unpublished data). C. gloeosporioides is frequently associated with Rhizoctonia spp. foliar blight. Both Colletotrichum spp. are seed-borne (Lenné 1981b).

Pod and leaf anthracnose caused by Colletotrichum sp. (Sonoda and Lenné 1979), has also occurred on C. pubescens and Centrosema spp. in the Pacific and Caribbean regions and U.S.A. (Appendix 2). In Florida, slight to moderate leaf spotting caused by C. gloeosporioides and C. truncatum was common on mature leaves of C. pubescens and C. virginianum (Lenné and Sonoda 1978).

Widely distributed leaf-spotting fungi. Curvularia pallescens and Curvularia spp. have been recorded from leaf spots on C. plumieri, C. pubescens and other species in French Guyana and Colombia (Appendix 1) and in Malaysia and Florida (Appendix 2). In Colombia, C. spp. were commonly associated with small, rounded, mid-brown coloured lesions which rarely caused serious damage. In Florida, leaf lesions incited by Curvularia spp. were found on 42 of 86 Centrosema accessions but incidence was low (Sonoda and Lenné 1979). These leaf spots are minor diseases.

Phoma spp. and the Phomopsis state of Diaporthe phaseolorum cause moderate to severe leaf spotting of Centrosema in several regions (Appendices 1 and 2). Both Phoma sorghina and the Phomopsis state of D. phaseolorum have been isolated from large, rounded to irregular, mid-brown coloured lesions (Figure 4) on leaves of C. macrocarpum, C. pubescens and C. acutifolium in Colombia and Brazil (CIAT 1985; Nasser, pers. comm.). Leaf spot and dieback caused by D. phaseolorum has also been recorded on C. pubescens in other regions (Appendix

2). In Colombia, isolates of *Phomopsis* sp. from Colombia and Brazil caused similar lesions on seedlings of the above mentioned species while only the Colombian isolate of *P. sorghina* was pathogenic.

The only leaf spotting fungus found to date in both tropical Latin America and other regions is the sooty mold *Meliola*. *M. denticulata* was recorded on *C. virginianum* in Brazil (Appendix 1) while *M. bicornis* has been recorded on *C. pubescens* and *C. virginianum* in Trinidad and U.S.A., respectively (Appendix 2). The importance of these diseases was not documented.

Localized leaf spotting fungi. Zonate leaf spot caused by *Cylindrocladium colhounii* causes moderate to severe defoliation of *C. pubescens* and *C. acutifolium* in the WDHS of Colombia (CIAT 1984). Lesions first appear as small, irregular, mid-brown spots which enlarge in zones of varying shades of brown (Figure 5). Affected leaves become chlorotic. This disease, although presently localized, is potentially serious under humid conditions.

Many other leaf spotting fungi have been recorded on *Centrosema* spp., but their distribution and importance is unknown (Appendices 1 and 2).

Fungi causing root[1], crown and collar diseases. In tropical Latin America, only two fungi have been found colonizing *Centrosema* roots. A *Fusarium* sp. was found in root lesions of *C. pubescens* in Carimagua, Colombia, but was not subsequently a problem (Appendix 1). Wilt and dieback caused by *Sclerotium rolfsii* were recorded on *C. brasilianum* in Santander de Quilichao,

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1/ Apart from *Rhizoctonia* spp.

Colombia. An isolate of S. rolfsii from Stylosanthes capitata was pathogenic to C. pubescens (Lenné 1979). These fungi are presently minor problems. In other regions of the world, soil borne diseases caused by several fungi have been recorded (Appendix 2).

Diseases caused by rusts. Three rusts have been recorded on Centrosema in tropical Latin America (Appendix 1). These are Puccinia sp. on C. virginianum in Venezuela (Standen, 1952), Uromyces neurocarpi on C. pubescens in El Salvador (Stevenson and Wellman 1944) and soybean rust Phakopsora pachyrhizi on C. pubescens in Puerto Rico (Vakili and Bromfield 1976).

Diseases caused by Rhizoctonia spp. Rhizoctonia solani and binucleate Rhizoctonia-like fungi (BNR) are regarded as the most damaging pathogens of Centrosema, particularly C. brasilianum, in tropical Latin America. Foliar blight caused by Rhizoctonia spp. has been recorded on C. acutifolium, C. arenarium , C. brasilianum, C. macrocarpum, C. pascuorum, C. plumieri, C. pubescens, C. schiedianum and C. virginianum throughout tropical America (Lenné et al 1983; Alvarez and Lenné 1983, 1986). Symptoms appear as small water-soaked lesions which increase in size becoming cream to light brown necrotic irregular spots which may involve whole leaflets (Figure 6). Profuse growth of fungal mycelium results in mats of leaves stuck together explaining the common use of the term "webblight". Sclerotia are common on blighted leaves (Figure 7). Foliar blight often commences in foci which enlarge under humid conditions causing considerable forage losses (Alvarez and Lenné 1986). Although the sexual stage Thanatephorus cucumeris has not yet been found in

Centrosema, the common initiation of the disease in foci at the beginning of the wet season suggests that the sexual stage may be involved.

Foliar blight caused by R. solani has been recorded on C. plumieri in Malaysia, Sierra Leone and New Guinea; on C. pubescens in Malaysia, Sarawak, New Guinea, New Hebrides, the Solomon Islands and Australia; and on several species of Centrosema in Florida (Appendix 2) (Johnson 1960; Williams and Liu 1976; Sonoda and Lenné 1979). Whether or not BNR were also present was not documented. In Florida, many accessions of C. brasilianum, C. plumieri (especially PI 330567) and C. pubescens were blighted (Sonoda et al. 1971).

Rhizoctonia spp. may also cause crown and root rot. BNR caused severe crown rot of isolated plants of C. macrocarpum in Palmira, Colombia in 1985.

BNR is commonly associated with foliar blight of Centrosema (Olaya and Lenné 1986). Approximately 50% of isolates collected from Centrosema leaves were BNR. In glasshouse seedling inoculations, many isolates of BNR were as virulent as R. solani (Olaya and Lenné 1986). In addition, R. zeae was also found associated with soil near blighted C. brasilianum plants (Alvarez and Lenné 1986). A complex of three species of Rhizoctonia is contributing to foliar blight of Centrosema spp. in Colombia and possibly elsewhere (Alvarez and Lenné 1986).

Initiation and development of foliar blight at the beginning of the wet season is favoured by high relative humidity, frequent rains and moderately high temperatures. The initial primary inoculum is probably sclerotia and/or sexual spores. Foliar blight is generally most severe during the first months of the wet season and commonly decreases in intensity toward the middle and end of the wet season. This will be discussed later. Sclerotia readily survive in soil for several years and are disseminated by wind, rain and animals. Fungal mycelium also survives with plant residues (Lenné et al. 1983).

Fungi with potential as biocontrol against Rhizoctonia spp. isolated from Centrosema leaves. Various fungi have been isolated from leaves of Centrosema spp. which may have a role in biological control of various pathogens. These include species of Gliocladium, Penicillium and Trichoderma (Appendices 1 and 2).

High populations of Gliocladium roseum, Penicillium spp. (including P. funiculosum), Trichoderma hamatum, T. harzianum and T. koningii were associated with leaves of moderately diseased plants of C. brasilianum (CIAT 1982, Alvarez and Lenné 1983). In vitro studies confirmed antagonism of these fungi to growth of R. solani mycelia (Figure 8), indicating they may naturally manage R. solani on Centrosema spp. In other countries, the association of fungi such as: Epicoccum nigrum, G. roseum, P. funiculosum, P. janthinellum, P. oxalicum and T. koningii (Appendix 2) may have potential for natural control of Rhizoctonia.

Other fungi. Pithomyces species, P. chartarum and P. maydicus have been found on C. pubescens in Malaysia (Appandix 2). The former produces a toxin responsible for photosensitization in animals. If profuse spore production occurs on Centrosema, P. chartarum could be a problem in Centrosema-based pastures. Several other fungi have been described on Centrosema spp. in various countries (Appendix 2).

Diseases caused by bacteria.

Pseudomonas fluorescens Biotype II was found to cause dieback and wilting of young plant parts of C. acutifolium, C. pubescens and to a lesser extent C. brasilianum, C. macrocarpum, C. schiedianum and C. virginianum in Colombia (Lenné et al. 1982; Guevara Gómez et al. 1983). C. acutifolium was the most susceptible species and Santander de Quilichao was the most favourable location. The disease is characterized by water-soaked lesions on young growth progressing into wilting, rotting, necrosis, dieback and defoliation of the plant. Necrotic spots develop on older leaves (Figure 9) (Guevara Gomez 1982; Lenné et al. 1983). Dry matter yields during the establishment of C. acutifolium were severely decreased (Guevara Gómez and Lenné 1983). Disease is favoured by high relative humidity and moderately high temperatures (Lenné et al. 1983). The bacterium can survive unfavourable periods on affected plants and in soil for up to six weeks (CIAT 1982). The bacterium is seed-borne; levels of infection as high as 32% have been found in some seed lots (Guevara Gómez 1982; Lenné et al 1982).

A Pseudomonas sp. leaf spot has been recorded as a minor disease of C. pubescens in North Queensland (R. Davis, pers. comm.). In addition to disease-causing Pseudomonas spp., other bacteria antagonistic to R. solani in vitro are resident on leaves of C. brasilianum with foliar blight. These include species of Acinobacter, Chromobacterium, Pseudomonas, Serratia, Bacillus and Enterobacter (Alvarez and Lenné 1983).

Diseases caused by mycoplasmas

Little leaf (witches broom or phyllody) caused by mycoplasma-like-organisms (MLO's) has been observed on various Centrosema species including C. brasilianum, C. macrocarpum, C. pubescens and C. acutifolium, C. virginianum and C. pascuorum in tropical America (Appendix 1) and Australia (Appendix 2). Symptoms appear initially as marginal and/or interveinal chlorosis accompanied by leaf deformation. Proliferation of shoots and leaves occurs from axillary buds with shortening of internodes and stunting. Proliferation of buds, leaves and branches increases progressively and plants become chlorotic and stunted. Fruiting ceases on affected portions. Work done on Clover Phyllody in Ireland (Joshi et al. 1967) showed that MLO's interfere with the ability of the plants to form symbiotic relationships with rhizobia which explains their chlorotic appearance.

MLO's are disseminated by leaf hoppers of the family Ciccadellidae, particularly Orosius agentatus Evans which has been recorded in Australia (Hutton and Grylls 1956) and Indonesia (Iwaki 1979), Scaphytopins fuliginosus (Granada, 1980) recorded in Colombia and various species of Agallia, Empoasca, Hortensia and Acinopterus in Florida (McCoy et al. 1983).

In recent years, build-ups of little leaf have occurred in small plots of C. brasilianum in the HT of Colombia, and in the well drained isothermic savannas (WDIS) of Brazil in C. macrocarpum, C. brasilianum and hybrids. Its incidence in pastures under grazing is being investigated at both sites.

Plant parasitic nematodes

M.R. Siddiqi (pers. comm.) at various sites in Colombia found four genera and eight species of parasitic nematodes associated with C. acutifolium, C. brasilianum, C. macrocarpum and C. pubescens in the well-drained isohyperthermic savannas (WDHS) of Colombia (Appendix 1).

In a greenhouse study, Lenné (1981) found C. pubescens CIAT 438 to be only slightly susceptible to Meloidogyne javanica. Charchar and Huang (1981) found commercial C. pubescens to be a good host of Pratylenchus brachyurus. M. javanica was observed on C. pubescens in Australia, (Lenné, pers. obs.), and M. sp. on C. pubescens in Cameroon (Atu and Obuji 1983) and the Philippines; however, yields were not reduced (Valdez 1976). Meloidogyne spp. have been recorded on C. plumieri and C. pubescens in Africa (Tapia 1971). In Florida, C. pubescens was resistant but C. pascuorum was severely galled by Meloidogyne spp. (Kretschmer et al. 1980).

Diseases caused by viruses

Worldwide, thirteen viruses have been described on Centrosema spp., mostly on C. pubescens (Appendix 3). These include como-, poty-, cucumo-, potex-, carla- and gemini-viruses.

The first reported was Centrosema Mosaic Virus (CaMV, CenMV), a potexvirus with particle length 580 nm, found in New Guinea (Magee 1954; van Velsen and Crowley, 1961; 1962; Crowley and Francki 1963; Purcifull and Edwardson 1981). CaMV can be transmitted by both aphids and plant bugs (van Velsen and Crowley, 1961) but is not seed-transmitted (Shaw, 1968). A second Centrosema Mosaic Virus (CeMV), a poty-virus with particle length 700 nm was isolated and characterized in Colombia in 1984 (F. Morales, pers. comm.; CIAT 1984, 1985; Appendix 3). Hosts included *C* *acutifolium*, *C. brasilianum*, *C. macrocarpum*, *C. pascuorum*, *C. pubescens*, *C. schottii* and *Glycine max*. It is transmitted by aphids and *seed-borne* at low levels (CIAT 1984, 1985; A. Neissen, pers. comm.).

In Colombia, CeMV causes chlorosis, mosaic, leaf deformation, stunting and plant death (CIAT 1984, 1985) (Figure 10). *C. macrocarpum* and *C. brasilianum* are most affected. The virus has been severe in sites with high aphid activity. Symptoms of CeMV are rarely detected in large pastures (5-20 ha) of *C. macrocarpum*, *C. brasilianum* or *C. acutifolium* in the WDHS of Colombia although the same hosts in nearby areas of high aphid activity are severely affected. Because the virus is seed-borne at low levels, there is a risk of introducing it to other regions.

A number of cowpea viruses (Apprneix 3) have been shown to have *Centrosema* spp. among their hosts. All have been recorded in Latin America. Passionfruit woodiness virus (PWV), a potyvirus with particle length 730-745 nm described from Australia (Teakle and Wildermuth, 1967; Greber 1971) attacks *C. pubescens*. PWV occurs as many different strains in Australia, and the *Centrosema* isolates are regarded as host selected variants of the virus (Greber, 1971). Whether or not PWV is seed-borne needs to be determined. PWV and CeMV are distinct viruses (J. Thomas pers. comm.). Several viruses affecting groundnut have been described on *Centrosema* spp. (Appendix 3).

Apart from descriptions of symptoms caused by these viruses and observations on the role of *Centrosema* spp. as a natural host, no indication has been given of their effect on Centrosema. Research is needed to completely characterize them, to determine their distribution and modes of transmission.

Arthopod Pests of Centrosema

Many references list species that have been collected or observed on Centrosema but little information is available concerning pest biology, distribution, severity of damage, population dynamics, or appropriate control measures. However some useful information can be gleaned from observations on other crops. Brief comments from the extensive literature are given.

The complex of pests which damage Centrosema will vary by locality, especially in small plots where neighbouring or previous crops, weeds, or other sources of infestation influence pest populations. For example, some soil-dwelling insects, particularly polyphagous rootfeeders, may present a temporary problem during establishment but decline over time if they are unable to complete their life cycle in Centrosema. Since its introduction in the 1940s to wet tropical areas of northern Australia, *C. pubescens* has been reported to be relatively free of major insect pests (Cameron 1984; Teitzel and Burt 1976). However, significant insect damage has been reported from Asia and Latin America. The following catalogue is a list of potential pests.

Thysanoptera

Thrips. *Taeniothrips sjöstedti* is present year-round on *C. pubescens* with peak populations during the main flowering period. Centrosema is a reservoir for thrips due to its habit of intermittent flowering over several months. *T.*

sjöstedti populations on C. pubescens do not reach the levels observed on cowpea due to the less succulent flowers and lower pollen production of centro (Taylor 1974). Thrips cause discoloration and distortion of flowers, loss of pollen, and reduced seed set (Taylor 1965). Thrips have caused moderate damage to Centrosema spp. in Peru (S.L. Lapointe pers. obs.).

Hemiptera and Homoptera

Plant-sucking bugs. During the dry season of 1986-1987, introduction plots of Centrosema in the Colombian savanna experienced a heavy infestation of a small black bug, Cyrtocapsus sp. (Miridae). It has been collected from Centrosema spp. in Brazil (Felixlandia and Belém), and from Stylosanthes spp. in southern Colombia and the Colombian savanna. There is a considerable range of susceptibility within Centrosema. C. acutifolium CIAT 5568 was least damaged (S.L. Lapointe, unpublished data).

Euschistus crenator (Pentatomidae) (Chinche). Stink bugs feed by sucking from pods and may damage seed and cause pod abscission and seed abortion. E. crenator has been reported feeding on Centrosema in Brazil, Peru and Colombia (Calderón and Arango 1985).

Aphids. Although high infestations of aphids during early growth can cause significant damage to many tropical legumes, aphids are more important as vectors of viral pathogens. Five of the 13 viruses reported on Centrosema spp. are transmitted by aphids (Appendix 3).

Leafhoppers. Various genera and species of Cicadellidae have been reported on Centrosema in Latin America (Calderón and Arango 1985). Empoasca spp. are especially common and cause damage by removing sap from the foliage. Severely attacked foliage turns yellow or brown with curling of the leaves resulting in characteristic "hopperburn".

Coleoptera

Leaf beetles. Adult Cerotoma and Colaspis spp. (Chrysomelidae) (bean leaf beetles) are leaf feeders; the larvae feed on bean roots (King and Saunders 1984). Cerotoma salvini and C. facialis have been reported from Costa Rica, Panama, Colombia, Peru, and Brazil (Nichols et al. 1974, King and Saunders 1984, Calderón and Arango 1985). In Brazil these have been observed attacking Centrosema.

Diabrotica balteata (Chrysomelidae) (banded cucumber beetle) feeds on a wide range of crop plants (King and Saunders 1984). It occurs in the United States, Central America, Cuba, Colombia, Venezuela and Peru (King and Saunders 1984, Pulido and Lopez 1973, Heyer and Cruz 1983). Together with Cerotoma facialis, D. balteata is considered to be the most important pest of common beans through direct damage to all parts of the plant and transmission of plant viruses (Gonzalez et al. 1982). Considerable information is available concerning biology and development (Heyer and Cruz 1983; Gonzalez et al. 1982) and the influence of tillage systems on oviposition and colonization (Vargas 1979, Shenk and Saunders 1984, Troxclair and Boetherl 1984). Compared with traditional field preparation, no-tillage systems maintain greater arthropod diversity including species of predators and parasites. Susceptibility of Centrosema to D. balteata may be greatest during sward establishment. Natural enemies of D. balteata include a tachinid fly, Solenopsis geminata, various Reduviidae, a Cantharid beetle and two species of nematode (King and Saunders 1984, Creighton and Fassuliotis 1982, 1985).

Lagria villosa (Lagriidae) is a common old world beetle (Spilman 1978). It was first reported in Brazil in 1976 (Pacheco et al. 1976). It attacks a great variety of crops (Peacock 1913, Lamborn 1914, Fröehlich & Rodeward 1970) and has been reported attacking inflorescences of Centrosema in Brazil (Ribeiro 1978). The adult beetle apparently enters diapause during the dry season in Brazil from June until December and is univoltine. Natural enemies include the fungus Paecilomyces sp. and a parasitoid Apanteles (Braconidae) (Garcia and Junior 1982). A tachinid fly has also been reported as a parasitoid of adults (Guimaraes 1978).

In Malaysia, C. pubescens suffers severe leaf damage from Epilachne indica (Coccinellidae), (Chee and Wong 1986). Naupactus spp. and Naupactaini sp. (Curculionidae) are especially damaging to Centrosema during the first months of the rainy season in Colombia. Burning adjoining areas at planting may reduce infestations (Spain 1982). This group of weevils may be only an initial pest following planting of Centrosema in an area previously occupied by native savanna. Similarly, Pantomorus sp. (Curculionidae) has caused damage to Centrosema in newly established plots in the WDHS of Colombia. It is not known if these weevils are capable of completing their life cycle in Centrosema.

Lepidoptera

Centrosema is attacked by the larvae of numerous lepidopterous species. Anticarsia gemmatalis (Noctuidae) (the velvetbean caterpillar) was reported on Centrosema in Brazil (Ribeiro 1978) and Colombia (Calderón and Arango 1985). It has been studied on other crops in Florida (Phronezny et al. 1981) and in Brazil where it is considered a major pest (Kogan et al 1977, Leite and Lara 1985). Eggs are laid on the underside of leaves. Larvae consume leaves and vines and can completely defoliate plants when populations are high. Parasitoids are listed by King and Saunders (1984). The fungus Nomuraea rilevi is a major biological control agent in larval populations of A. gemmatalis (Hinds and Osterberger 1931, Allen et al. 1971, Carnaret et al. 1975, Leite and Lara 1985, Correa et al. 1977). An inexpensive pheromone trapping system for A. gemmatalis has been developed (Mitchell and Heath 1986).

Phurys basilians (Noctuidae) and Etiella zinckenella (Phycitidae) (legume pod borer, limabean pod borer) have been reported on Centrosema in Brazil (Ribeiro 1978). E. Zinckenella is parasitized by Bracon sp., Tetrastichus sp., and Pteromalid sp.

Urbanus proteus (Hesperidae), (bean-leafroller) is reported to attack Centrosema in Brazil (Ribeiro 1978). U. proteus is an endemic pest of Phaseolus vulgaris in northern Chile apparently well controlled by natural enemies including Chalcid wasps (Dias 1976). It is also a minor pest of beans and other legumes in Central America (King and Saunders 1984). In Colombia, U. proteus feeding on P. vulgaris are parasitized in the egg stage by Trichogramma sp. and as larvae by Ardalus sp. (Hymenoptera) and Calpodomyia sp. (Diptera) (Dam and Wilde 1977).

Elasmopalpus lignosellus (Pyralidae) was found on Centrosema in Colombia in August 1986 (S.L. Lapointe pers. comm.). In Central America, E. lignosellus is of sporadic or local importance in sandy or well-drained soil during the dry season and after burning. Denser planting may be helpful and a fallow period reduces infestation. Eggs are placed singly or in small groups on the stems and leaves that are close to the soil and on the surface of the soil at the base of host plants (King and Saunders 1984).

Hedylepta indicata (Pyralidae) (leaf-folder) attacks Centrosema in Cuba during the rainy season. Larvae are leaf-rollers and feed on leaf parenchyma. Kapoor et al. (1972) reported eulophids, braconids and ichneumonids as larval parasites. Life history data and laboratory rearing techniques have been published (Kapoor et al. 1972, Bortoli et al. 1982). In recent years, population densities of H. indicata have grown notably in various regions of Brazil with high infestations of soybean fields during 1982/83 (Lourencao et al. 1985).

Diptera

Bean fly, Melanagromyza centrosematis (Agromyzidae) is a minor pest of Centrosema in Malaysia (Clements et al. 1983). In North Queensland, M. phaseoli lays its eggs on the leaves of Centrosema and other legumes, usually on the upper surface. Heavy infestations will thin out legume stands (G.W.

Saunders and R.J. Elder, unpublished memos). Seed treatment with Eldrin or Dieldrin has been recommended before planting. However, treatment will damage *Rhizobium* inoculum on the seed surface.

Mites

In Australia, Colombia, and Florida (U.S.A.), red spider mites (*Tetranychus* sp.) attack *Centrosema* foliage (Clements et al. 1983).

Distribution and relative importance of diseases and pests across major ecosystems of tropical Latin America

Diseases and pests of *Centrosema* vary in distribution and importance among the major ecosystems of tropical Latin America (Lenné et al. 1985; Pizarro 1983, 1985). *Rhizoctonia* foliar blight is by far the most important disease in three major ecosystems (Table 1). Its secondary importance in the WDIS is probably due to the short wet season in this ecosystem. *Cercospora* leaf spot and *Pseudocercospora* leaf spot are generally considered of secondary importance with the exception of the latter disease in savanna ecosystems (Table 1). Recently severe damage has been recorded on *C. brasilianum* CIAT 5234 in Planaltina and Carimagua suggesting that *P. bradburyae* has potential to be a serious pathogen (CIAT 1984).

Cylindrocladium leaf spot has been recorded as a secondary disease in the WDHS ecosystem. *Colletotrichum* spot and pod lesion is widespread, but is regarded as a secondary disease. Pod anthracnose causes concern because seed from infected pods generally carries at least one species of *Colletotrichum*.

The Phoma/Phomopsis leaf spotting complex is a secondary disease in both savanna ecosystems and has not yet been detected in the humid tropics (Table 1). At present, bacteriosis caused by *Pseudomonas fluorescens* Biotype II is viewed as a site-specific problem of importance as a seed-borne pathogen. Similarly, Centrosema Mosaic Virus (CeMV) is viewed in the same way because at present it is only of importance at one site (Table 1). Little leaf has caused severe damage in small plots under cutting.

Leaf-eating insects, principally Chrysomelidae and other Coleoptera, cause significant damage to *Centrosema* across the major ecosystems of Latin America (Pizarro 1985, Table 2). Judging from visual ratings, the greatest damage occurs during the wet season in the WDHS and WDIS and during the dry season in the poorly drained savannas and HT ecosystems.

Further monitoring at major screening sites is needed to determine whether some diseases and pests will build up in ecosystems where presently they are unimportant. Differences in the importance of diseases and pests in different ecosystems necessitates research on most of them. Currently, most research on the status of diseases and pests is being done at CIAT. Ideally, it should be done in the ecosystem where the particular disease or pest is most important.

Relative importance of various diseases among Centrosema species

Centrosema species vary in the relative importance of various diseases. No case has yet been found of a disease being important on all the promising species. Bacteriosis is the most host-specific disease, and *C acutifolium* is the species most susceptible to it (Table 3). Cercospora leaf spot is more important on *C. pubescens* than other species, *Pseudocercospora* leaf spot is more important on *C. brasilianum*, and *Cylindrocladium* leaf spot on *C. acutifolium*. Anthracnose is slightly more important on *C. brasilianum* and *C. pubescens* than other species because of its association with *Rhizoctonia* foliar blight and tendency to cause pod anthracnose on these species. *Phoma*/*Phomopsis* leaf spot complex is more important on *C. acutifolium* and its hybrids than on *C. pubescens* and *C. macrocarpum*.

For several years, differential susceptibility among *Centrosema* species to *Rhizoctonia* spp. has been observed, *C. brasilianum* being the most susceptible (CIAT 1981-1983; Alvarez and Lenné, 1986).

C. brasilianum and *C. macrocarpum* are more affected by little leaf, and *C. macrocarpum* is more affected by Centrosema Mosaic Virus, than other species. In both cases, observations are site specific and care should be taken in their interpretation. Controlled experiments are required to confirm field observations.

Variability Within Centrosema Species for Resistance to Diseases

Rhizoctonia foliar blight

Field experiments at several sites have given hope that susceptibility to

Rhizoctonia Foliar Blight may vary within Centrosema species. In Florida, Sonoda et al. (1971) observed apparent differences in susceptibility within C. plumieri and other species. However, in tropical South America, screening of C. brasilianum has shown that most accessions are moderately to severely blighted (CIAT 1980-85; Lenné et al. 1985; Schultze-Kraft et al. 1985). More than [illegible] accessions have been tested in these field trials.

Some of the experiments have shown poor agreement among replications (CIAT, 1984). Small plot evaluations of reaction to Rhizoctonia foliar blight among C. brasilianum accessions using only natural inoculum are not of great value in selecting resistant accessions. An improved field screening methodology is presently being developed.

Development of artificial inoculation using liquidized frozen mycelium has greatly improved the uniformity of results of studies on reaction of Centrosema spp. seedlings to Rhizoctonia spp. isolates (CIAT 1985). In several studies variation in reaction to Rhizoctonia species among accessions of C. brasilianum, C. macrocarpum, C. pubescens and C. acutifolium has been noted. Most accessions of C. macrocarpum are inherently highly susceptible (Olaya and Lenné 1986). In selection for resistance to Rhizoctonia foliar blight within C. brasilianum, both field evaluation and artificial inoculation will be necessary. The major problem with artificial inoculation studies will be choice of isolate which should be representative of the ecosystem and/or site for which C. brasilianum is being selected. A range of isolate virulence should be included.

Bacteriosis

Accessions of *C. acutifolium* in Santander de Quilichao, Colombia varied in reaction to *P. fluorescens* Biotype II (CIAT 1980, 1981; Guevara Gómez, 1982; Schultze-Kraft and Keller-Grein, 1985). CIAT 5112 and 5118 were highly susceptible while 5568 was more resistant. Controlled artificial inoculation studies confirmed results obtained in the field (Guevara Gómez 1982). Some accessions have continued to show high resistance across major ecosystems.

Centrosema Mosaic Virus (CeMV)

C. macrocarpum accessions differed in reaction to CeMV in Santander de Quilichao and Carimagua, Colombia during 1984 to 1985 (CIAT 1984, 1985). Considerable variability was also observed among plants within accessions. Screening under controlled conditions is clearly necessary.

Other diseases

Variability has been observed at several sites in reaction to Cercospora leaf spot, anthracnose, little leaf and various other diseases within promising species such as *C. brasilianum*, *C. macrocarpum*, *C. pubescens* and *C. acutifolium*. Controlled screening for disease resistance is needed to back up field results.

Variability Among Important Pathogens

Variability within the Rhizoctonia spp. complex

Studies on more than 200 isolates have shown the presence of at least three species: *R. solani*, *R. zeae* and BNR (Olaya 1985; Alvarez and Lenné 1986; CIAT 1986). Olaya and Lenné (1986) showed that *R. solani* and BNR were more virulent and common than *R. zeae*. Isolates vary in growth rate, colour, zonation, sclerotial characters, mycelial texture and virulence. Multinucleate isolates of *R. solani* have been classified as AG-1, AG-2 and AG-4 with AG-1 and AG-4 being more common. Further variation within these groups was detected from isozymes bands (Olaya 1985). Of a collection of 180 isolates of *Rhizoctonia* spp. only 44% were *R. solani*, 56% being BNR (Olaya and Lenné 1986). In comparative pathogenicity trials, high levels of virulence were registered for isolates of both *R. solani* and BNR (Alvarez and Lenné 1986, Olaya and Lenné 1986).

Because foliar blight of *Centrosema* is caused by a variable complex of *Rhizoctonia* species and types, studies of resistance under controlled conditions are complex and long-term. Priority will be given to determining the most common types of *Rhizoctonia* in specific sites to obtain resistance information as soon as possible. Studies on the effect of environmental conditions on population dynamics should also be given priority.

Variability within Colletotrichum spp.

Both *C. gloeosporioides* and *C. truncatum* are involved in leaf and pod anthracnose of Centrosema spp. Although both species can be isolated from the same lesions particularly from pods, C. gloeosporioides is more commonly isolated from leaves (Lenné et al. 1983). Some variation in virulence has been found within C. gloeosporioides. Most isolates of C. truncatum are not pathogenic to seedlings. No evidence of variability has yet been observed among other Centrosema pathogens.

Seed-Borne Pathogens

General studies

Seed microflora of Centrosema includes species of Aspergillus, Chaetomium, Fusarium, Mucor, Penicillium, Rhizopus, Trichoderma and bacteria. The occurrence of Chaetomium, Penicillium and Trichoderma offers potential for natural biological control. In addition, several important pathogens of Centrosema spp. were detected including the bacterium P. fluorescens Biotype II, Colletotrichum spp. and Centrosema mosaic virus.

P. fluorescens Biotype II

Treatment of C. acutifolium seeds with chemicals such as Kocide and Vitavax were successful in lowering infection with this bacterium but not in eliminating it (Salas and Lenné 1986). At present, contaminated seed is only being used for local plantings to prevent movement of this pathogen outside Colombia. Further work is planned using dry heat which successfully eliminates another Pseudomonas species from rice seed (R. Zeigler, pers. comm.).

Colletotrichum spp.

The association of *Colletotrichum* spp. with seed of *Centrosema* spp. (Lenné 1981b) is important for pathogen movement but also because of their negative effect on germinating seedlings (Lenné and Sonoda 1978). Both Benlate and Difolatan were successful in eliminating *C. gloeosporioides* and *C. truncatum* from seed of *C. pubescens* (J. Lenné, unpubl. data).

Centrosema Mosaic Viruses

Studies made on CaMV in New Guinea found no evidence of seed infection (Shaw, 1968). Low levels of seed infection, however, have been detected by ELIZA for CeMV in Colombia (A. Neissen, pers. comm.). Further work is necessary to define infection levels and species of *Centrosema* involved, but at present, this virus is not causing serious damage unless introduced into sites with high aphid activity.

Options for Disease and Pest Management

Options for disease and pest management include chemical, biological and cultural control (sanitation and grazing management), strategic association, and resistance (Lenné et al. 1980, Lenné 1983). Resistance is the most practical and economical option for pasture plants. All *Centrosema* germplasm is screened for reaction to local pests and pathogens at major CIAT screening and RIEPT sites. Back up glasshouse screening is necessary for some pathogens and pests. The chemical basis of resistance to several pathogens has been observed in *Centrosema* spp. Accessions of *C. schottii* (Syn. *C. haitiense*), *C.*

pubescens and *C. virginianum* produced phytoalexins and phenolic compounds when inoculated with *R. solani* (Markham and Ingham 1980, Sukumaran and Gnanamanickam 1980). These compounds included tectorigenin, cajanin, kievitone, phaseollidin and coumestrol.

The use of chemicals to control diseases and pests will be uneconomical in most cases. In addition, cattle tolerance to residues, toxicity to insect pollinators, as well as the problems of resurgence of pests and diseases are important biological constraints. Pesticides, however, have some value in management of seed-borne pathogens where economic injury levels are lower and toxic residues are of less concern.

Plants growing under higher fertility often show greater resistance to diseases (Leath and Ratcliffe 1974) but results to date do not encourage use of specific fertilizers as an option for management of *Centrosema* diseases (CIAT 1983; Lenné 1983). Biological control agents of many *Centrosema* pests have been identified, but this option is largely unexplored for tropical pasture plants. Some work has been done on natural control agents of *Rhizoctonia* species in the WDHS ecosystem. During 1981-1986, decrease or lack of build-up in the incidence and severity of foliar blight during the wettest period of the year were found to be associated with high populations of *Trichoderma* spp., *Gliocladium roseum*, *Penicillium* spp. and various bacteria (Alvarez and Lenné 1983, CIAT 1982). Antagonism of the above fungi and bacteria to isolates of *R. solani* was demonstrated *in vitro*. Build-up of these micro-organisms could explain natural decreases in foliar blight.

To date, neither sanitation by burning nor strategic association have been investigated for control of diseases of Centrosema. The effect of grazing management on foliar blight and yield of C. brasilianum CIAT 5234 has been studied (Alvarez and Lenné, 1986). Losses ranging from 34 to 54% dry matter have been greatest under continuous grazing and in association with Andropogon gayanus. Not only does the grass favour disease development, possibly due to competition for nutrients and light and/or by creating a more favourable microclimate for disease development, but also the grazing animal apparently aids dissemination of Rhizoctonia through the pasture.

Research Priorities

The following research priorities can be defined in order of importance for diseases of Centrosema.

Rhizoctonia foliar blight

Improved methodology for evaluating resistance under field conditions will be studied immediately. Isolate variability is being examined to provide representative isolates for glasshouse screening. The value of associated antagonistic fungi and bacteria as natural biological control agents of foliar blight also needs to be evaluated under field conditions. Further work is needed on epidemiology and the effect of grazing and association on foliar blight incidence and severity.

Centrosema mosaic virus

Of high priority is a comparative study of the similar mosaic causing viruses recorded on Centrosema spp. Information available from previous studies could be of use in investigating CeMV in Colombia. Care must be taken in movement of seed especially of C. macrocarpum as CeMV is seed-borne. Further work on CeMV will also involve evaluation of Centrosema germplasm for resistance.

Cercospora leaf spot

A confusing complex of Cercospora spp. has been described on Centrosema spp. throughout the world. As the last detailed treatment of this genus was made more than thirty years ago (Chupp 1953), comparative work is needed to determine whether we are actually dealing with four different diseases. Prior to initiation of any breeding programs, such a study is essential.

Phoma/Phomopsis complex

Further work is necessary to elucidate the importance of these fungi and relationships between them. This is particularly important in the WDIS where soybean cultivation is increasing. The Phomopsis state of Diaporthe phaseolorum is an important pathogen of this crop.

Potentially plant parasitic nematodes

Recent surveys by M.R. Siddiqi, particularly in the WDHS ecosystem, found four genera and eight species of parasitic nematodes in Centrosema based pastures. Further work is urgently needed to evaluate the importance of these nematodes to Centrosema.

Mycoplasma-like-organisms

Little leaf seems to be a problem of small plots and not large grazing experiments. This observation requires further investigation as does the site-specific nature of this disease.

Very little specific information is available about insect pests of Centrosema. Research on specific pests causing significant damage should increase as the distribution and importance of Centrosema increases. We need to know the relative importance of individual pests, their distribution and the damage they cause. Such data will allow us to develop appropriate control strategies and to establish priorities for plant breeding programs.

Acknowledgements

The senior author would like to thank the Commonwealth Mycological Institute, Kew, Surrey, U.K. for access to their unpublished records of diseases recorded on Centrosema.

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LIST OF FIGURES

Table 1. Distribution and relative importance of various diseases[a] of *Centrosema* spp. across major ecosystems of Tropical Latin America.

Disease	Ecosystem			
	Savanna		Humid Tropics	
	Isohyperthermic (Llanos) (WDHS)	Isothermic (Cerrados) (WDIS)	Rainy	Seasonal
Cercospora leaf spot (*C. canescens*)	S	S	S	S
Pseudocercospora leaf spot (*P. bradburyae*)	S/I S	S/I S/I	[illegible] [illegible]	NI NI
Cylindrocladium leaf spot (*C. colhounii*)	S	–	–	–
Anthracnose (*Colletotrichum* spp.)	S	S	S	S
Phoma/*Phomopsis* complex leaf spot (*Phoma* spp.; *Diaporthe phaseolorum*)	S	S	–	–
Rhizoctonia foliar blight (*Rhizoctonia* spp.)	I	S	I	I
Bacteriosis (*Pseudomonas fluorescens* Biotype II)	NI	–	–	I[b]
Little leaf or Phyllody	NI	S/I	NI	S/I
Centrosema Mosaic Virus (CeMV)	NI	–	–	I[b]

I = Important; S = Secondary; NI = Not Important; – Not detected.
(Source: Modified from Lenné et al. 1983).

a Only better known and/or widely distributed diseases are included.

b Importance rating at present pertains to one site only.

Table 2. Leaf-eating insect damage to *Centrosema* across some major ecosystems of tropical Latin America.

Ecosystem*	Season of greatest damage	Most Damaged species	Least damaged species
WDHS	Wet	*C. acutifolium*	*C. pubescens*
WDIS**	Wet	*C. acutifolium*	*C. macrocarpum*
PDIS	Dry	*C. macrocarpum*, *C. acutifolium*	*C. arenarium*
HT(TRF)	Dry	*C. macrocarpum*	*C. virginianum*
HT(SRF)	Dry	*C. pubescens*	*C. brasilianum*

* WDHS = Well-drained isohyperthermic savannas
WDIS = Well-drained isothermic savannas (cerrados)
PDIS = Poorly-drained isohypertiermic savannas
HT = Humid tropics
TRF = Tropical rain forest
SRF = Seasonal rain forest

** Only two species evaluated.

Table 3. Relative importance of various diseases* among promising species of *Centrosema*.

Diseases	Species			
	C. brasilianum	*C. macrocarpum*	*C. pubescens*	*C. acutifolium*
Cercospora leaf spot (*C. canescens*)	NI	S	I/S	NI
Pseudocercospora leaf spot (*P. bradburyae*)	I/S	NI	NI	NI
Cylindrocladium leaf spot (*C. colhounii*)	NI	NI	S	I/S
Anthracnose (*Colletotrichum* spp.)	S	NI	S	NI
Phoma/Phomopsis spp. complex leaf spot (*Phoma* spp.; *Diaporthe phaseolorum*)				
Rhizoctonia foliar blight (*Rhizoctonia* spp.)	I	S	S/I	I/S
Bacteriosis (*Pseudomonas fluorescens* Biotype II)	NI	NI	S	I
Little leaf or Phyllody	S/I	S/I	S	S
Centrosema Mosaic Virus (CeMV)	S/I	I	S	S

I = Important; S = Secondary; NI = Nor Important; - = Not detected.
(Source: modified from Lenné et al., 1983).

* Only better known and/or widely distributed diseases are included.

APPENDIX 1

Diseases[a] of Centrosema spp. across mayor ecosystems of tropical Latin America

Pathogen	Disease	Host species	Country	Ecosystem	Reference
FUNGI:					
Cercospora canescens Ell.& Mart.	Leaf spot	C. arenarium C. brasilianum C. pascuorum C. plumieri C. pubescens C. schiedianum C. acutifolium	Bolivia, Brazil Colombia, Ecuador, Peru, Venezuela Central America French Guyana	WDHS WDIS HT MAS	CIAT (1980-85) Lenné et al. (1983) Lenné (1981a) Lenné (pers.surv.) Bereau (1981) Chupp (1953) Schultze-Kraft & Keller-Grein (1985) Sonoda & Lenné (1979)
Cercospora centrosemae Chupp & Muller	Leaf spot	C. virginianum	Venezuela	?	Chupp (1953)
Cercospora cylindrospora Stev. & Sond.	Leaf spot	C. pubescens C. virginianum	Mexico	?	Chupp (1953)
Colletotrichum gloeosporioides (Penz.) Sacc. Colletotrichum truncatum	Leaf spot & Pod anthracnose	C. arenarium C. brasilianum C. macrocarpum C. pascuorum C. plumieri C. schiedianum C. virginianum C. acutifolium	Bolivia, Brazil Colombia, Ecuador Perú, Venezuela Central America	WDHS WDIS HT MAS	Lenné (1981a) Lenné et al.(1983) Lenné (pers.surv.) Schultze-Kraft & Keller-Grein (1985)
Curvularia pallescens Boedijn	Leaf spot	C. plumieri C. pubescens	French Guyana	HT	Bereau (1981)
Curvularia spp.	Leaf spots	C. pubescens C. spp.	Colombia	WDHS	Lenné (pers.surv.) Sonoda & Lenné (1979)

Appendix 1 (Cont'd)

Pathogen	Disease	Host species	Country	Ecosystem	Reference
Cylindrocladium colhounii Peer.	Zonate leaf spot	C. brasilianum C. macrocarpum C. pubescens C. acutifolium	Colombia	WDHS	Lenné (pers.surv.)
Fusarium sp.	Root lesions	C. pubescens	Colombia	WDHS	Lenné (pers.surv.)
Linhartia sp.	White leaf blotch	C. arenarium	Brazil	WDIS	Lenné (pers.surv.)
Meliola denticulata Wint.	Sooty mold	C. virginianum	Brazil	?	CMI(unpubl.records)
Phoma sorghina (Sacc.) Boer. Dorenboch. & van Kest.	Leaf spot	C. macrocarpum C. acutifolium	Colombia Brazil	WDHS WDHS	Nasser (per.surv.) Lenné (pers.surv.)
Phomopsis state of Diaporthe phaseolarum (Cooke & Ellis) Sacc.	Leaf spot	C. macrocarpum C. pubescens C. acutifolium	Brazil Colombia	WDIS WDIS	CIAT (1985) Lenné (pers.surv.)
Phyllachora galactiae Earle	Tar spot	C. virginianum	Venezuela	?	Standen (1952)
Pseudocercospora bradburyae (Young) Deighton	Leaf spot	C. arenarium C. brasilianum C. macrocarpum C. pascuorum C. plumieri C. pubescens C. schiedianum C. virginianum C. acutifolium	Bolivia, Brazil Colombia, Ecuador Perú, Venezuela Central America	WDHS WDIS HT MAS	CIAT (1985) Lenné et al. (1983) Lenné (pers.surv.) Sonoda & Lenné (1979) Schultze-Kraft & Keller-Grein (1985)

Appendix 1 (Cont'd)

Pathogen	Disease	Host species	Country	Ecosystem	Reference
Puccinia sp.	Rust	C. virginianum	Venezuela	?	Standen (1952)
Rhizoctonia solani Kuhn.	Foliar blight (webblight)	C. arenarium C. brasilianum C. macrocarpum C. pascuorum C. plumieri C. pubescens C. schiedianum C. virginianum C. acutifolium	Bolivia, Brazil Colombia, Ecuador Peru, Venezuela Central America	WDHS WDIS HT MAS	CIAT (1980-1985) Lenné (1981a) Lenné et al. (1983) Lenné (per.surv.) Alvarez & Lenné (1983, 1986) Sonoda & Lenné (1979) Schultze-Kraft & Keller-Grein (1985)
Binucleate Rhizoctonia-like fungi	Foliar blight Crown rot	C. brasilianum C. pubescens C. acutifolium	Colombia	WDHS	Olaya & Lenné (1986) CIAT (1985)
Sclerotium rolfsii Sacc.	Wilt and dieback	C. brasilianum C. pubescens	Colombia	HT	Lenné (pers.surv.) Lenné (1979)
Uromyces neurocarpi Diet.	Rust	C. pubescens	El Salvador	GHS	Crandall et al. (1951) Stevenson & Wellman (1944)
BACTERIA: Pseudomonas fluorescens Biotype II	Bacterial wilt & dieback	C. brasilianum C. macrocarpum C. pubescens C. schiedianum C. virginianum C. acutifolium	Colombia	HT WDHS	Lenné et al. (1982) Lenné et al. (1983) Guevara et al. (1983) Schultze-Kraft & Keller-Grein (1985) CIAT (1980)-84)

APPENDIX 3

Viruses recorded on Centrosema spp. throughout the world

Virus	Group	Particle length nm	Distribution	Host Range	Transmission	References
Centrosema Mosaic Virus (CaMV, CenMV)	Potexvirus	580	New Guinea	Centrosema pubescens Crotalaria spp. Calopogonium muconoides Desmodium distortum Non-hosts: Glycine max Phaseolus vulgaris var. Bountiful Vigna unguiculata	Aphididae: Brachycaudus helichrysi var. warei A. craccivora A. gossypi Myzus persicae Lygaeidae: Nysius (green) Nysius (brown) Non-transmission by seed	Magee (1954) Van Velsen & Crowley (1961) Crowley & Francki (1963) Purciful & Edwardon (1981) Van Velsen & Crowley (1962) Van Velsen & Crowley (1962) Shaw (1968)
Centrosema Mosaic Virus (CeMV)	Potyvirus	700	Colombia	√Centrosema spp. √Macroptilium sp. Dioclea sp. Crotalaria spp. Desmodium distortum Glycine max Phaseolus vulgaris vars. Bountiful, Double white	Aphididae: Aphis spp. Myzus persicae Seed transmission at low levels	Morales (pers.comm.) CIAT (1984-1985)
Cowpea Mosaic Virus	Comovirus	30	Cuba El Salvador	Centrosema spp. Vigna unguiculata Rhynchosia pyramidalis	Chrysomelidae Non-transmission by seed	Diaz (1974)
Cowpea Severe Mosaic Virus Serotype I (CPSMV)	Comovirus	?	Brasilia, Brazil	Centrosema pubescens Calopogonium muconoides Vigna radiata	 Vigna unguiculata	Lin et al. (1982)

Appendix 3. (Cont'd)

Virus	Group	Particle length nm	Distribution	Host Range	Transmission	References
Cowpea Blackeye Mosaic Virus (BlCMV)	Potyvirus	?	Brazil	<u>Centrosema pubescens</u> <u>Vigna unguiculata</u>	Seed transmission	Lin et al. (1981)
Cowpea Potyvirus (unclassified)	Potyvirus	700-750	Brazil	<u>Centrosema brasilianum</u> <u>Vigna unguiculata</u>	Aphididae: <u>Aphis craccivora</u> Non-transmission by seed	Lima et al. (1981)
Cucumber Mosaic Virus (CMV)	Cucumovirus	30	Guadeloupe	<u>Centrosema pubescens</u> <u>Macroptilium atropurpureum</u>		Migliori et al. (1978)
Groundnut Rosette Virus*	?	?	Ivory Coast Uganda	<u>Centrosema</u> spp. <u>Arachis</u> spp. <u>Gliricidia sepium</u> <u>Macroptilium atropurpureum</u>	Aphididae <u>Aphis craccivora</u>	Davies (1972)
Groundnut Crinckle Virus (GCV)	Carlavirus		Ivory Coast	<u>Arachis</u> spp. <u>Centrosema pubescens</u>	Non-transmission by aphids	Dubern (1981)
Groundnut Eyespot Virus	Potyvirus		Ivory Coast	<u>Arachis</u> spp. <u>Centrosema pubescens</u>	Aphididae: <u>Aphis craccivora</u>	Dubern & Dollet (1978)
Yellow Mottle Virus	Geminivirus		Colombia	<u>Centrosema</u> spp.		Lenné (pers. observ.)
Passionfruit Woodiness Virus (PWV)	Potyvirus	730-745	Australia	<u>Centrosema pubescens</u> <u>Crotalaria</u> spp. <u>Glycine max</u> <u>Phaseolus vulgaris</u> <u>Arachis hypogea</u>		Teakle & Wildermuth (1967) Greber (1971)
Golden Mosaic Virus	Geminivirus	?	Cuba	<u>Centrosema pubescens</u>		Lenné (pers.observ.)

* Needs Groundnut Rosette Asistor Virus.

Appendix 2 (Cont'd)

Pathogen	Disease	Host species	Region	Country	Reference
Pseudocercospora bradburyae (cont.)		C. virginianum	Caribbean	Puerto Rico	Chupp (1953)
				Barbados	Chupp (1953)
				Santo Domingo	Chupp (1953)
				Trinidad	Chupp (1953)
Pyrenochaeta sp.	Leaf spot	C. pubescens	Asia	Hong Kong	CMI (unpubl.rec.)
Rhizoctonia solani Kuhn.	Foliar Blight	C. brasilianum	North America	U.S.A.	Lenné & Sonoda (1979)
		C. plumieri	Asia	Malaysia	CMI (unpubl.rec.)
			Africa	Sierra Leone	CMI (unpubl.rec.)
			Pacific	New Guinea	CMI (unpubl.rec.)
			North America	U.S.A.	Lenné & Sonoda (1979)
		C. pubescens	Asia	Sarawak	Johnson (1960)
				Malaysia	Williams & Liu (1976)
			Africa	Ghana	CMI (unpubl.rec.)
			Pacific	New Guinea	CMI (unpubl.rec.)
				New Hebrides	CMI (unpubl.rec.)
				Solomon Islands	CMI (unpubl.rec.)
				Australia	J. Hopkinson (pers.comm.)
			North America	U.S.A.	Lenné & Sonoda (1979)
Rosellina bunodes		C. pubescens	Asia	India	Sonoda & Lenné (1979)

Appendix 2 (Cont'd)

Pathogen	Disease	Host species	Region	Country	Reference
Phoma minutella Sacc. & Penz.	Leaf spot	C. pubescens	Pacific	Solomon Islands	CMI (unpubl.rec.)
Phoma sorghina (Sacc.) Boer, Dorenb. & van Kest.	Leaf spot	C. pubescens	Africa	Uganda	CMI (unpubl.rec.)
Phoma sp.	Leaf spot	C. pubescens	Pacific	New Guinea	CMI (unpubl.rec.)
Phyllosticta sp.	Leaf spot	C. pubescens	Asia	Malaysia	Williams & Liu (1976)
				Borneo	CMI (unpubl.rec.)
Pseudocercospora bradburyae (Young) Deighton (syn: Cercospora bradburyae Young)	Leaf spot	C. plumieri	Pacific	New Guinea	Sonoda & Lenné CMI (unpubl.rec.)
		C. pubescens	Africa	Ghana	CMI (unpubl.rec.)
				Guinea	CMI (unpubl.rec.)
				Nigeria	CMI (unpubl.rec.)
			Asia	Malaysia	Johnson (1960) Singh (1973)
				Thailand	CMI (unpubl.rec.)
				Hong Kong	CMI (unpubl.rec.)
				Borneo	CMI (unpubl.rec.)
				Brunei	CMI (unpubl.rec.)
			Caribbean	Jamaica	CMI (unpubl.rec.) Leather (1967)
			Pacific	Australia	R.Davis(pers.comm.
				New Guinea	CMI (unpubl.rec.)
				Solomon Islands	CMI (unpubl.rec.)
				Fiji	Firman (1972)

Appendix 2 (Cont'd)

Pathogen	Disease	Host species	Region	Country	Reference
Fusarium semitectum Berk. & Rav.		C. pubescens	Pacific	New Guinea	CMI (unpubl.rec.)
Fusarium decemcellulare Brick		C. pubescens	Asia	Malaysia	Williams & Liu (1976)
Leptosphaeria sp.	Leaf spot	C. pubescens	Caribbean	Trinidad	CMI (unpubl.rec.)
			Pacific	New Hebrides	CMI (unpubl.rec.)
Leptosphaerulina trifolii (Rostr.) Petrak	Leaf spot	C. pubescens	Africa	Uganda	CMI (unpubl.rec.)
			Pacific	Solomon Islands	CMI (unpubl.rec.)
Meliola bicornis Wint.	Sooty mold	C. pubescens	Caribbean	Trinidad	Baker & Dale (1951)
		C. virginianum	North America	U.S.A.	Sonoda & Lenné (1979)
Nematospora spp.		C. plumieri	Africa	Congo(?)	Sonoda & Lenné (1979)
Neocosmospora vasinfecta Smith		C. pascuorum	Pacific	Australia	CMI (unpubl.rec.)
Neurospora sitophila Shear & Dodge		C. pubescens	Asia	Malaysia	CMI (unpubl.rec.)
Nigrospora sphaerica (Sacc.) Mason	Leaf spot	C. pubescens	Asia	Malaysia	CMI (unpubl.rec.)
Oidium sp.		C. pubescens	Asia	Sri Lanka	Sonoda & Lenné (1979)
			Pacific	Australia	R.Davis (per.comm.)
Periconia byssoides Pers.	Leaf spot	C. pubescens	Asia	Malaysia	CMI (unpubl.rec.)
Phakopsora pachyrhizi Syd.	Soybean rust	C. pubescens	Caribbean	Puerto	Vakili & Bromfield

Appendix 2 (Cont'd)

Pathogen	Disease	Host species	Region	Country	Reference
Colletotrichum gloeosporioides (Penz.) Sacc.	Leaf spot & Pod anthracnose	*C. pubescens*	Pacific North America Caribbean	Australia U.S.A. Barbados	R.Davis (per.comm.) Sonoda & Lenné (1979) Norse (1974)
Colletotrichum truncatum	Leaf spot	*C. pubescens*	North America	U.S.A.	Sonoda & Lenné (1979)
Colletotrichum sp.	Leaf spot & Pod anthracnose	*C. pubescens* *C.* sp.	North America Pacific Caribbean	U.S.A. New Guinea Puerto Rico	Sonoda & Lenné (1979) CMI (unpubl.rec.) CMI (unpubl.rec.)
Coniothyrium sp.	Leaf spot	*C. pubescens*	Asia Pacific	Sarawak New Guinea	Turner (1971) CMI (unpubl.rec.)
Curvularia pallescens Boedijn	Leaf spot	*C. plumieri*	Asia	Malaysia	CMI (unpubl.rec.)
Curvularia spp.	Leaf spot	*C. pubescens*	North America	U.S.A.	Sonoda & Lenné
Diaporthe phaseolorum (Cooke & Ellis) Sacc.	Leaf spot & dieback	*C.* spp. *C. pubescens*	Caribbean	Trinidad Barbados	Baker & Dale (1951) CMI (unpubl.rec.) Norse (1974)
Didymosphaeria sp.		*C. pubescens*	Pacific	New Guinea	CMI (unpubl.rec.)
Drechslera sp.	Leaf spot	*C.* spp.	North America	U.S.A.	Sonoda & Lenné (1979)
Fomes lignosus		*C. pubescens*	Asia	India	Sonoda & Lenné (1979)

APPENDIX 2

Diseases[a] of Centrosema spp. in other regions and countries of the tropics

Pathogen	Disease	Host species	Region	Country	Reference
FUNGI:					
Alternaria macrospora Zimm.	Leaf spot	C. pubescens	Africa Pacific	Uganda Australia	CMI (unpubl.rec.) R.Davis (per.comm.)
Ascochyta sp.	Leaf spot	C. pubescens	Africa	Uganda Zimbabwe	CMI (unpubl.rec.)
Botryodiplodia theobromae Pat.	Dieback	C. pubescens	Asia Africa	Malaysia Ghana	CMI (unpubl.rec.)
Cercospora canescens Ell. & Mart.	Leaf spot	C. plumieri	Pacific Africa Asia Caribbean	Australia Sudan Malaysia Barbados	Alcorn (1972) Tarr (1955) CMI (unpubl.rec.) Norse (1974)
C. centrosematicola Yen & Lim	Leaf spot	C. pubescens	Asia	Malaysia	Yen & Lim (1973)
C. centrosematis Chupp. & Muller	Leaf spot	C. pubescens	Caribbean Asia	Puerto Rico Philli-ppines	CMI (unpubl. rec.)
C. clitoriae Atk.	Leaf spot	C. virginianum C. sp.	North America	U.S.A.	Chupp (1953)
C. cylindrospora Stev. & Sond.	Leaf spot	C. pubescens C. virginianum	Caribbean	Puerto	Chupp (1953)
C. sp.	Leaf spot	C. pubescens	North America	U.S.A.	Sonoda & Lenné (1979)
Cochliobolus geniculatus Nelson		C. pubescens	Asia	Malaysia	CMI (unpubl.rec.)
C. lunatus Nelson & Haasis		C. pubescens	Asia Pacific	Malaysia New Guinea	CMI (unpubl.rec.)

Appendix 2 (Cont'd)

Pathogen	Disease	Host species	Region	Country	Reference
Sclerotium rolfsii Sacc.	Wilt & dieback	C. pubescens	Asia	Malaysia	Singh (1973) Thompson & Johnso (1953)
Sclerotium bakeri Syd		C. pubescens	Asia	Malaysia	Singh (1973) Thompson & Johnso (1953)
Xylaria thwaitesii		C. pubescens	Asia	India	Sonoda & Lenné (1979)
BACTERIA:					
Pseudomonas sp.	Leaf spot	C. pubescens	Pacific	Australia	R.Davis (pers.com
MYCOPLASMAS:					
Mycoplasma-like-organisms	Phyllody	C. pubescens	Pacific	Australia	Simmonds (1966)
		C. pascuorum	Pacific	Australia	R.Clements(pers.c
		C. virginianum	Pacific	Australia	
NEMATODES:					
Heterodera oryzae	Cyst nematode	C. pubescens	Africa		Merny & Cadet (1978)
Meloidogyne javanica	Root-knot	C. pubescens	Pacific	Australia	Lenné (per.surv.)
		C. pascuorum	Pacific	Australia	Clements (1986)
Meloidogyne incognita	Root-knot	C. plumieri	Africa		Luc & Guiran (1960)
		Centrosema sp.	Africa	Cameroon	Atu & Obguji (1983)
		C. pubescens	Asia	Philli-ppines	Valdez (1976)
Meloidogyne spp.	Root-knot	C. plumieri	Africa		Tapia (1971)
		C. pubescens	Asia	Malaysia	Beeley (1939)
		C. pascuorum	North America	U.S.A.	Kretschmer et al. (1980)
		C. virginianum	North America	U.S.A.	Bratley (1946)

Appendix 1 (Cont'd)

Pathogen	Disease	Host species	Country	Ecosystem	Reference
P. zeae		C. acutifolium	Colombia	WDHS	M.R.Siddiqi (per. surv.)
Tylenchulus sp. nov.		C. brasilinaum	Colombia	WDHS	M.R.Siddiqi (per. surv.)

a/= Excluding viruses.
* = Listed as synonym Cercospora bradburyae Young.
WDHS = Well-drained isohyperthermic savannas
WDIS = Well-drained isothermic savannas
HT = Humid tropics
MAS = Moderately acid soils
GHS = Glasshouse study

Appendix 1 (Cont'd)

Pathogen	Disease	Host species	Country	Ecosystem	Reference
MYCOPLASMAS:					
Mycoplasma-like-organisms	Phyllody, little leaf Witches broom	C. brasilianum C. macrocarpum C. pubescens C. acutifolium	Brazil Colombia Peru, Venezuela, Central America	WDHS WDIS HY MAS	Lenné (1981a) Lenné (Pers.surv.) Schultze-Kraft & Keller-Grein (1985)
NEMATODES:					
Ditylenchus spp.		C. brasilianum	Colombia	WDHS	M.R.Siddiqi (per. surv.)
Helicotylenchus dihystera		C. brasilianum	Colombia	WDHS	M.R.Siddiqi (per. surv.)
H. pseudopaxilli		C. acutifolium	Colombia	WDHS	M.R.Siddiqi (per. surv.)
Helicotylenchus sp. nov.		C. brasilianum	Colombia	WDHS	M.R.Siddiqi (per. surv.)
Meloidogyne javanica		C. pubescens	Colombia	GHS	Lenné (1981b)
Pratylenchus brachyurus		C. brasilianum C. acutifolium	Colombia	GHS	Charchar & Huang (1981)
		C. macrocarpum & C. pubescens	Colombia	WDHS	M.R.Siddiqi (per. surv.)
P. teres		C. brasilianum C. acutifolium C. macrocarpum	Colombia	WDHS	M.R.Siddiqi (per. surv.)

Appendix 1 (Cont'd)

Pathogen	Disease	Host species	Country	Ecosystem	Reference
MYCOPLASMAS:					
Mycoplasma-like-organisms	Phyllody, little leaf Witches broom	C. brasilianum C. macrocarpum C. pubescens C. acutifolium	Brazil, Colombia Peru, Venezuela, Central America	WDHS WDIS HT MAS	Lenné (1981) Lenné (pers.surv.) Schultze-Kraft & Keller-Grein (1985)
VIRUSES:					
Centrosema Mosaic Virus (CsMV)	Mosaic, leaf deformation, stunting chlorosis	C. acutifolium C. brasilianum C. macrocarpum C. pascuorum C. pubescens C. schottii C. acutifolium	Colombia	HT, WDHS	CIAT (1984-85) Lenné (pers.surv.)
Cowpea Mosaic Virus	Mosaic & leaf deformation	C. plumieri	Cuba	?	Kvicala et al. (1972)
		C. pubescens	El Salvador	?	Diaz (1973)
Cowpea Severe Mosaic Virus	Mosaic	C. pubescens	Brazil	WDIS	Lin et al. (1982)
Blackeye Cowpea Mosaic Virus (BICMV)	Mosaic & leaf curling	C. pubescens	Brazil	WDIS	Lin et al. (1981)
Unclassified Cowpea Poty Virus	Mosaic & leaf deformation	C. brasilianum C. pubescens	Brazil	WDIS	Lima et al. (1981)
Gemini Virus	Yellow mottle	C. macrocarpum C. pubescens C. acutifolium	Colombia	HT	Lenné (pers.surv.)

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