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DISEASE AND PEST PROBLEMS OF STYLOSANTHES

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ABSTRACT

Diseases caused by eleven genera of fungi, one bacterium, one mycoplasma, two viruses and four genera of nematodes have been described on *Stylosanthes*. Anthracnose is the most widespread and damaging disease and active research programs are in progress in several countries. In South America, variation among isolates of *C. gloeosporioides* appears to be related to the natural distribution of various *Stylosanthes* species. Other important diseases include web blight and Botrytis head blight in Australia and little leaf mycoplasma in Brazil.

Thirty-six pests representing eighteen families and four orders have been recorded on *Stylosanthes*. The stemborer *Caloptilia* sp. in South America and *Platyomopsis pedicornis* in Australia are the most important. Stable resistance to *Caloptilia* sp. has been found.

Although resistance is the basic control method being sought, use of nutrients and strategic burning may have a role in disease control. Biological control combined with resistance is considered of most value in pest control. In South American *Stylosanthes* species centers of diversity, use of the natural diversity within species as cultivar blends is considered a logical approach to disease and pest control.

INTRODUCTION

Prior to 1970, few diseases and pests had been described on *Stylosanthes* species. Diseases and pests as potential limiting factors to production had received almost no attention. During the past decade, great expansion of research on *Stylosanthes* in Australia and South America; establishment and expansion of research programs in South-east Asia, the Pacific, Africa and Florida and the accompanying increased movement of seed; and entry of plant pathologists and entomologists into tropical

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pasture research has lead to recognition of many diseases and pests of this genus.

After ten years, plant pathologists in Australia, Florida and South America have identified anthracnose as the most damaging disease of Stylosanthes and research programs are actively studying means of controlling this disease. During the past five years, the stemborer Caloptilia sp. has been recognized as a damaging pest of Stylosanthes in South America and control studies are well advanced. However many diseases and pests are poorly documented and their importance is presently unknown. Clearly, much research is needed on diseases and pests of Stylosanthes.

This paper reviews diseases and pests recorded on Stylosanthes. Where information was available, the importance, distribution and ecology of diseases and pests are discussed. Control is briefly reviewed with respect to the South American situation.

DISEASES OF STYLOSANTHES

Diseases caused by fungi

Anthracnose (Colletotrichum spp.)

Anthracnose is caused by the fungi Colletotrichum gloeosporioides and C. dematium, the former being the more important pathogen (Lenné and Sonoda 1978a;Shipton 1979). Since it was first reported on Stylosanthes sp. in Brazil (Anon. 1937), anthracnose has become a widespread and damaging disease (Lenné et al. 1980) affecting Stylosanthes spp. in the Americas (Sonoda et al. 1974; Lenné and Sonoda 1979; Anon. 1981); Australia (O'Brien and Pont 1977; Irwin and Cameron 1978); Asia (Humphreys 1980); and Africa (Clatworthy 1975; Maraite 1981).

During 1977 to 1979, anthracnose caused 26 to 58 per cent loss of dry matter in S. hamata in southern Florida (Lenné and Sonoda 1982). In Colombia, 64 to 100 per cent loss and reduction in nutritive value were recorded in S. guianensis from 1980 to 1981 (Lenné unpublished data), while in Africa, 80 per cent loss was found in S. guianensis (Maraite 1981). Although not quantified in Australia, serious losses in seed crops and pastures of S. hamata, S. humilis and S. guianensis have been recorded (O'Brien and Pont 1977; Irwin and Cameron 1978). The importance of anthracnose is clearly evident.

The etiology of anthracnose of Stylosanthes; life cycles of the causal fungi; differential host reactions and the genetics of the host-pathogen interaction; epidemiology and survival; and screening methodology have been thoroughly reviewed (Irwin et al. 1982). The distribution and ecology of C. gloeosporioides will be briefly discussed.

Most species of Stylosanthes are indigenous to the savannas of the Americas (Mohlenbrock 1957). This region therefore includes the centers of diversity of most Stylosanthes species. The center of diversity of a plant is also the center of diversity of its specialized pathogens (Leppik 1970). Extensive surveys of mostly undisturbed indigenous populations of Stylosanthes species in Brazil, Colombia and Venezuela have found the widespread occurrence of anthracnose (Lenné unpublished data). Anthracnose fungi and Stylosanthes are intimately associated within the centers of diversity of Stylosanthes species.

During 1978 to 1981, systematic anthracnose evaluation of S. capitata, indigenous to the acid infertile soils of Brazil and Venezuela (Grof et al. 1979), found 84.3 per cent accessions susceptible in Brazil and only 10 per cent accessions in Colombia, strongly suggesting existence of specialized S. capitata isolates of C. gloeosporioides in Brazil (Lenné 1982a).

Over the past four years, seedling screening has identified eight different groups of isolates of C. gloeosporioides on Stylosanthes species in South America according to their host ranges (Lenné et al. 1982). Studies with isolates from Brazil and Colombia have confirmed that several groups of specialized S. capitata isolates exist in Brazil and not in Colombia. Isolates pathogenic to widely distributed S. guianensis occur in Brazil, Colombia, Peru and Venezuela (Lenné et al. 1982). There is growing evidence that the geographical distribution of isolate groups is related to the natural distribution of their Stylosanthes hosts. Classification of pathogenic variation within C. gloeosporioides continues as a high research priority with the aim of identifying the best screening sites for promising species.

It is believed that anthracnose fungi were introduced from South America to Australia probably on infected Stylosanthes seed (Cameron personal communication). Seed transmission is believed to be responsible for the rapid spread of anthracnose in northern Australia (Irwin and Cameron 1978). Although pathogenic variation among Australian isolates of C. gloeosporioides has been identified (Irwin et al. 1982), the susceptibility of resistant Australian accessions and cultivars to anthracnose in South America (Lenné unpublished data) strongly suggests the occurrence of more pathogenic variants in South America.

Comparison of isolates of C. gloeosporioides from Stylosanthes spp. from Thailand, Solomon Islands and from S. guianensis from Africa with isolates from Australia have found no differences (Lenné unpublished data). It is probable that these isolates were introduced into the respective countries on infected seed from Australia.

Surveys during 1979 failed to find C. gloeosporioides on native stands of S. hamata on the southeast coast of Florida (Sonoda and Brolmann 1980). Restriction of anthracnose to Stylosanthes species at the Agricultural Research Center, Fort Pierce strongly suggests introduction on infected seed from South America (Sonoda personal communication).

The importance of infected seed in the global movement of anthracnose of Stylosanthes is clearly evident. As plant collection and introduction is a continuing activity future chance introductions of C. gloeosporioides isolates from South America to other countries are highly likely. As was previous recommended (Lenné et al. 1980), screening Stylosanthes germplasm for resistance to anthracnose in South America should be of high priority.

Blight (Sclerotium rolfsii)

Sclerotium rolfsii has been recorded on S. humilis in Australia (Simmonds 1966) and Florida (Sonoda 1974); on S. capitata in Colombia and Brazil (Lenné 1979; Anon. 1980); and on S. scabra in Thailand (Lenné unpublished data). In Colombia, affected plants wilted and died. White mycelium and brown sclerotia were commonly observed on lower stems of affected plants and on the soil surface (Lenné 1979).

Although S. rolfsii affected only S. capitata in the field in Colombia, it was highly pathogenic to S. guianensis, S. hamata, S. humilis, S. macrocephala, S. scabra, S. viscosa and S. capitata in greenhouse trials (Lenné 1979). From 1979 to 1981, surveys found means of 5% S. capitata plants killed by S. rolfsii and 2.7 viable sclerotia per 100 grams of soil in Carimagua, Colombia (Anon. 1981). Blight is presently regarded as a minor disease of Stylosanthes spp.

Web Blight (Rhizoctonia solani)

In northern Queensland, web blight has damaged pastures of S. hamata, S. humilis and, to a lesser extent, S. guianensis during the wet season since 1973 (O'Brien and Pont 1977). Although extensive areas of dead foliage matted together with fungal mycelium are commonly seen, losses have not been measured.

Rhizoctonia solani has also been recorded as a pathogen of S. humilis in Florida (Sonoda 1974) and S. guianensis in Zambia (Sonoda 1974) and Peru (Lenné unpublished data). Infection is usually associated with warm, humid conditions (Sonoda 1974; O'Brien and Pont 1977; Lenné unpublished data).

Botrytis Head Blight (Botrytis cinerea)

Since 1970, Botrytis head blight has caused yield losses in seed crops of Stylosanthes spp. in northern Queensland (O'Brien and Pont 1977). The fungus causes extensive blossom blighting and apical dieback. Under wet conditions conducive to disease development, grey-coloured mould grows over the inflorescences (O'Brien and Pont 1977). Apart from detection on S. guianensis and S. hamata at San Jose del Nus, Colombia in 1979, B. cinerea has not been recorded on Stylosanthes spp. outside of Australia.

Rhizopus Seedling and Inflorescence Diseases (Rhizopus spp.)

Rhizopus stolonifer affected seedling emergence and greatly reduced seedling survival of S. hamata in Florida (Lenné and Sonoda 1978b). Seed dressing with the fungicide Difolatan was an effective control.

Rhizopus sp. caused severe inflorescence blighting and girdling in S. capitata in Carimagua, Colombia in 1980 and 1981 (Anon. 1981). Symptoms were similar to Rhizopus head rot of sunflower (Rogers et al. 1978). It is thought to be insect-borne and studies of its importance are in progress.

Other diseases caused by fungi

Various leaf diseases have been recorded on Stylosanthes spp. Curvularia sp. caused minor leaf spotting on Stylosanthes spp. in Florida (Sonoda 1974). Cercospora stylosanthes has been recorded on Stylosanthes sp. in Paraguay (Chupp 1953); C. commonsii on S. biflora in Delaware (Chupp 1953); and C. canescens on S. guianensis in Malawi (Thomas 1973). The importance of these leaf spots is unknown. Cercospora sp. caused slight damage to S. guianensis cv. Endeavour in Pucallpa, Peru in 1981 (Lenné unpublished data). The rounded dark brown to black spots with chlorotic halos were readily distinguished from anthracnose damage. Stylosanthes sp. was slightly affected by C. personata and C. arachidicola in greenhouse inoculations (Sonoda 1974).

Black smut has been recorded on S. guianensis (Tuley 1968) and sooty mold, caused by Capnodium sp., has been observed on upper surfaces of leaves of S. guianensis in Colombia (Lenné unpublished data). The slime mould, Physarum sp., has occasionally been found on S. capitata during the wet season in Colombia (Lenné unpublished data). It probably reduced yield by reducing photosynthesis.

Bark splitting and canker caused by Botryosphaeria ribis occasionally killed two to three year old plants of S. capitata and S. scabra in Colombia and Brazil in 1980 and 1981 (Anon. 1981). Diplodia collar rot (Tuley 1968) and black root rot (Corticium invisum) in India (Sonoda 1974) have been recorded on S. guianensis. Black stem spotting caused by Phoma sp. has been found on Stylosanthes spp. in Nigeria (Sonoda 1974) and Phoma sorghina as a seed-borne pathogen of S. guianensis and S. humilis in Australia (Wan Zainun Nik and

Parbery 1975). Two Pythiums - P. butleri on S. guianensis in Queensland (Alcorn 1972) and P. aphanidermatum on S. humilis in Florida (Sonoda 1974) caused root rot and death of potted plants and transplants, respectively. The importance of these diseases has not yet been determined. In Carimagua, Colombia, Macrophomina phaseolina killed 1% young plants of S. capitata in 1980 (Lenné unpublished data) and is presently considered a minor pathogen of Stylosanthes spp.

Diseases caused by bacteria, mycoplasmas and viruses

Bacterial Wilt (Pseudomonas solanacearum)

Bacterial wilt is widespread in S. humilis pastures in the higher rainfall regions of the Northern Territory (Aldrick 1971). Usually it causes only moderate damage.

Little Leaf Mycoplasma

Under field testing in southern Queensland in the 1950's, many species and accessions of Stylosanthes spp. were susceptible to little leaf spread by the leaf hopper Orosius argentatus (Hutton and Grylls 1956). Symptoms were manifest as chlorosis; leaf puckering; proliferation of stems and small leaves; and plant death within one to two years. S. erecta, S. fruticosa and S. montevidensis were severely affected. Little leaf was not regarded as important due to field resistance of various accessions (Hutton and Grylls 1956).

Although not yet investigated in detail, little leaf is the most important disease of S. scabra in the cerrados of Brazil (Thomas personal communication). Eighty per cent of accessions under evaluation at the Cerrado Center have been severely affected by little leaf (Lenné and Thomas unpublished data). S. capitata, S. macrocephala and S. viscosa are slightly affected. Progressive loss of plant yield and vigour caused by little leaf is partly due to the mycoplasma reducing effectiveness of nodulation by Rhizobium (Joshi et al. 1967). Further studies are in progress.

Other diseases

Mild mottle virus has been recorded on *S. humilis* in Kenya and groundnut rosette virus on *Stylosanthes* spp. in Malawi (Sonoda 1974). The importance of these viruses is unknown.

Nematodal diseases

In Australia, the root knot nematodes *Meloidogyne javanica* and *M. arenaria*, have been recorded on *S. sundaica* (Colbran 1958) and *S. guianensis* (Colbran 1964) and on *Stylosanthes* sp. (Blake 1963), respectively. *Radopholus similis* has been found on *S. humilis* (Colbran 1964). In Nigeria, Caveness (1967), found *S. guianensis* to be a host of *Scutellonema clathricaudatum* and *Helicotylenchus pseudorobustus*. The damage caused by these nematodes was not documented.

A root knot nematode moderately damaged native stands of *S. guianensis* in Minas Gerais, Brazil in 1980 and 1981 (Lenné and Sousa Costa unpublished data). In a pot trial, 18 accessions of seven *Stylosanthes* species were not affected by *M. javanica* from *Desmodium ovalifolium* (Lenné 1981). Variation in reaction to a root knot nematode was found within *S. guianensis* CPI 34911 in south-east Africa (Clatworthy 1982). Nematode resistant plants were readily selected.

PESTS OF STYLOSANTHES

It is most apparent from the literature that there is considerably less information about pests of *Stylosanthes* species than diseases.

During 1978 to 1980, the Entomology section of CIAT's Tropical Pastures Program conducted an insect population survey by periodically sampling insects associated with tropical pasture plants at two sites in Colombia (Calderon 1981). Results for *Stylosanthes* are summarized in Table 1.

Sucking insects of the families Cicadellidae, Pentatomidae and Tingidae were commonly recorded (Table 1). These families and Cercopidae have also been recorded on Stylosanthes spp. in Thailand (Pimiamarn personal communication). In Colombia, S. capitata is damaged more than other species (Calderón unpublished data). Significant decreases in percentages of phosphorus, potassium and sulphur have been measured in affected leaves (Calderón unpublished data).

Chewing insects of the family Chrysomelidae are most common (Table 1). In Thailand, this family and Bruchidae were commonly recorded (Pimiamarn personal communication). Dry matter losses caused by Chrysomelidae averaging 2.8 per cent per month have been recorded in five accessions of S. capitata in Santander de Quilichao, Colombia (Calderón unpublished data).

Stemborers (Caloptilia sp.; Platyomopsis pedicornis)

Two important stemborers damage Stylosanthes: Caloptilia sp. (Lepidoptera: Gracilariidae) in Brazil and Colombia and Platyomopsis pedicornis (Coleoptera: Cerambycidae) in Queensland.

Caloptilia sp. is the major pest of Stylosanthes in South America (Calderón 1981). The Lepidoptera larvae tunnel through lower stems considerably weakening susceptible accessions of S. guianensis and S. scabra which usually die within two years. Field screening has identified accessions of S. capitata and S. guianensis resistant to stemborer (Calderón 1981). Results from oviposition and feeding preference tests indicated that the mechanism of resistance could be an antibiotic effect (Calderón 1981). Anatomical and stem hardness studies showed that susceptible accessions possessed thinner layers of sclerenchyma cells and were harder than resistant accessions (Calderón and Varela 1982). Host plant resistance studies are continuing to further define characteristics of resistant plants, of value in future germplasm collection.

A different stemborer, P. pedicornis, was recently detected on S. scabra at three sites in Queensland (Hall 1980). Larvae hollowed the taproot and lower main stem, killing all plants in a 0.3 ha area. Other Stylosanthes spp. were not attacked.

Larvae of the stemborer Prosoplus torosa (Coleoptera: Cerambycidae) have also been observed on S. scabra in Queensland (Hall 1980). In addition, a stemborer (Coleoptera: Curculionidae), causing galls on lower stems, has been recorded on S. capitata in Venezuela and on S. guianensis and S. scabra in Brazil (Calderón unpublished data). Their importance is unknown.

Budworm (Stegasta bosquella)

The budworm, Stegasta bosquella, reduces seed production of S. guianensis in South America (Calderón 1981). Late flowering accessions are damaged more by this insect. Those species with high seed production potential, including S. capitata and S. macrocephala, are less affected than S. guianensis (Calderón 1981). Studies are in progress on critical levels of damage caused by budworm in Stylosanthes spp. Although it has a world-wide distribution, the pest status of budworm on Stylosanthes spp. has been reported only from South America.

Other pests

Stylosanthes guianensis is attacked by psyllids, termites and larvae of the leaf miner Hedylepta diemenalis in southern Florida (Duke 1978). A leaf miner (Coleoptera: Chrysomelidae) has also been recorded on S. capitata and S. guianensis in Colombia (Calderón unpublished data). In northern Queensland, caterpillars cause minor damage to flowers and seed heads of Stylosanthes spp. while root feeding weevil larvae, Leptopius sp., have sometimes caused damage (Hopkinson and Loch 1977). Control measures are considered unnecessary. Termites have also been recorded on S. scabra in Queensland (Hall 1980), Stylosanthes spp. in South America (Calderón unpublished data) and on S. guianensis in Africa (Lazier personal communication).

CONTROL OF DISEASES AND PESTS OF STYLOSANTHES.

Control of diseases and pests of tropical pasture plants has been previously reviewed (Lenné et al. 1980). It was concluded that although resistance has limitations, it is a practical and economical control method with great potential in tropical pasture plants.

In Australia (Irwin et al. 1982) and South America (Anon. 1981) resistance to anthracnose is being actively sought by glasshouse and field screening, selection and breeding in several Stylosanthes species. In South America, where pathogenic variation within C. gloeosporioides is related to the natural distribution of Stylosanthes hosts, multilocational field screening is essential (Lenné 1982a). Stable host plant resistance to the stemborer, Caloptilia sp., has been identified in S. capitata in Colombia (Calderón and Varela 1982). Screening for resistance to these problems, sucking insects of the order Homoptera and little leaf mycoplasma are continuing in South America.

Although nutrients have been found to affect diseases and pests of several tropical pasture legumes (Lenné and Calderón unpublished data), no effect on pests and diseases of Stylosanthes has been observed. Further studies are in progress. During 1979 to 1980, burning dramatically reduced anthracnose by 60-77.5 per cent in S. capitata in Colombia (Lenné 1982b). It was therefore recommended to consider burning as a control when no other practical temporary control measures are available.

Biological control agents of all major Stylosanthes pests have been identified in South America (Calderón unpublished data). Their importance and contribution to control is being studied. A combination of resistance and biological control in an integrated pest management programme will probably prove the best method of controlling pests of tropical pasture plants (Lenné et al. 1980).

Specialized pathogens and pests are closely associated with their hosts in the centers of diversity of Stylosanthes species in South America. Greater variation exists within pathogens in their centers of diversity than elsewhere (Leppik 1970). Studies are in progress to classify this diversity in anthracnose fungi (Lenné et al. 1982).

Browning (1974) was the first to emphasize the relevance of knowledge learned from natural ecosystems to development of pest management programs for agroecosystems. Studies of diseases of small grains in Israel (Browning 1974, 1979; Wahl et al. 1978); diseases of white clover in Wales

(Burdon 1978); and indigenous pathogens of natural forests (Schmidt 1978) have found low disease levels and stable non-epidemic situations due to the heterogenic composition of natural plant communities. Application of host diversity with respect to disease resistance as oat multilines to control crown rust (Browning et al. 1979) and mixtures of barley cultivars to control powdery mildew (Wolfe et al. 1981) has been successful.

Methodologies including multilocational screening in centers of diversity; evaluation of mixtures of susceptible and resistant accessions; and selection for diversity of resistance are being developed for control of anthracnose. The recent release in Colombia of S. capitata as a blend of five accessions from different geographical locations (Anon. 1982) was directed at future anthracnose control. In South American centers of diversity of Stylosanthes species where understanding of variation in natural populations of C. gloeosporioides and other pathogens and pests will require many years of research, use of the natural diversity within Stylosanthes species as cultivar blends seems a logical approach to disease and pest control.

TABLE 1. Insects commonly recorded on *Stylosanthes* spp. at Santander de Quilichao and Carimagua, Colombia from 1978 to 1980.

Insect	Order[1]: Family	Habit
Parallaxis donaldsoni	Hom: Cicadellidae	Foliage: Sucking
Parallaxis guzmani[3]	Hom: Cicadellidae	Foliage: Sucking
Agallia lingula	Hom: Cicadellidae	Foliage: Sucking
Graminella sp.[2]	Hom: Cicadellidae	Foliage: Sucking
Ciminius hartii[2]	Hom: Cicadellidae	Foliage: Sucking
Empoasca sp.[2]	Hom: Cicadellidae	Foliage: Sucking
Cuerna striata[3]	Hom: Cicadellidae	Foliage: Sucking
Cimerogonalia lituriceps[3]	Hom: Cicadellidae	Foliage: Sucking
Oncometopia orbona[3]	Hom: Cicadellidae	Foliage: Sucking
Oncometopia sp.[3]	Hom: Cicadellidae	Foliage: Sucking
Ceresa vitulus[2]	Hom: Membracidae	Foliage: Sucking
Chaectonema sp.[2]	Col: Chrysomelidae	Foliage: Chewing
Colaspis sp.	Col: Chrysomelidae	Foliage: Chewing
Pachybrachys sp.[2]	Col: Chrysomelidae	Foliage: Chewing
Diabrotica speciosa[3]	Col: Chrysomelidae	Foliage: Chewing
Lamproshaerus sp.[3]	Col: Chrysomelidae	Foliage: Chewing
Apion sp.	Col: Curculionidae	Inflorescence: Bollweevil
Stilbus sp.	Col: Phalacridae	Foliage: Chewing
Epicauta sp.[3]	Col: Meloidae	Unknown
Corythucha costata[2]	Hem: Tingidae	Foliage: Sucking
Corythaica carinata[2]	Hem: Tingidae	Foliage: Sucking
Alydus sp.[2]	Hem: Alydidae	Foliage: Sucking
Euschistus crenator[2]	Hem: Pentatomidae	Foliage: Sucking
Geocoris sp.[2]	Hem: Lygaeidae	Foliage: Sucking
Pseudopachybrachis vincta[3]	Hem: Lygaeidae	Foliage: Sucking
Bracon sp.	Hym: Braconidae	Parasite: Lepidoptera
Orgilus sp.	Hym: Braconidae	Parasite: Lepidoptera
Chelonus sp.[2]	Hym: Braconidae	Parasite: Lepidoptera
Horismenus sp.[2]	Hym: Eulophidae	Parasite: Lepidoptera
Augochlora sp.[2]	Hym: Halictidae	Inflorescence: Chewing
Caloptilia sp.	Lep: Gracilariidae	Stemborer
Stegasta bosquella	Lep: Gelechiidae	Budworm

1. Hom = Homoptera; Col = Coleoptera; Hem = Hemiptera; Hym = Hymenoptera; Lep = Lepidoptera.
2. Recorded in Santander de Quilichao only
3. Recorded in Carimagua only

REFERENCES

Alcorn, J. L. (1972). Some new records of Queensland fungi. Qld. Jour. Agric. Anim. Sci. 29, 73-77.

Aldrick, S. J. (1971). Bacterial Wilt (Pseudomonas solanacearum) of Stylosanthes humilis in the Northern Territory. Trop. Grassl. 5, 23-26.

Anon. (1937). Informacaos sobro algumas plantas forrageiras. Minsterio da Agricultura, Rio de Janeiro, 1937.

Anon. (1981). Centro Internacional de Agricultura Tropical (CIAT). Annual Report Tropical Pastures Program, Cali, Colombia.

Anon. (1982). Centro Internacional de Agricultura Tropical (CIAT). Annual Report Tropical Pastures Program, Cali, Colombia.

Blake, C. B. (1963). Identification and distribution of root-knot nematodes (Meloidogyne spp.) in New South Wales with special reference to the Richmond - Tweed Region. Proc. Linn. Soc. N.S.W. 38, 373-378.

Browning, J. A. (1974). Relevance of knowledge about natural ecosystems to development of pest management programs for agroecosystems. Proc. Am. Phytopath. Soc. 1, 191-199.

Browning, J. A. (1979). Genetic protective mechanisms of plant-pathogen populations: their coevolution and use in breeding for resistance. pp. 52-75. In: "Biology and Breeding for Resistance to Arthropods and Pathogens in Agricultural Plants". Ed. M. K. Harris. Texas, 1979.

Browning, J. A., Frey, K. J., McDaniel, M. E., Simons, M. D. and Wahl, I. (1979). The biologic of using multilines to buffer pathogen populations and prevent disease loss. Indian J. Genetics and Pl. Breed. 39, 3-9.

Burdon, J. J. (1978). Mechanisms of disease control in heterogeneous plant populations-an ecologists view. "In "Plant Disease Epidemiology". Ed. P.R. Scott and A. Bambrigde. pp. 193-200. Blackwell; Oxford.

Calderón, M. (1981). Insect pests of tropical forage plants in South America. Proc. XIV Int. Grassl. Congress, Kentucky, June 1981 (in press).

Calderón, M. and Varela, F. (1982). Resistencia de Stylosanthes spp. al barrenador del tallo. Bol. Inform. Pastos Trop. CIAT. 6, 1-3.

Cameron, D. F., O'Brien, R. G. and Irwin, J. A. G. (1980). Screening species of Stylosanthes for resistance to anthracnose disease. Proc. Aust. Agron. Conf. Lawes, Qld. April 1980. p. 228.

Caveness, F. E. (1967). Shadehouse host ranges of some Nigerian nematodes. Plant Dis. Rep. 51, 33-37.

Chupp, C. (1953). A monograph of the fungus genus Cercospora. Ithaca, New York. 667 pp.

Clatworthy, J. N. (1975). Introduction and preliminary screening of pasture legumes at Marandellas, Rhodesia, 1967-73. Proc. Grassl. Soc. South Afr. 10, 56-63.

Clatworthy, J. N. (1982). Global adventures in Stylosanthes - S. E. Africa. Symposium - The Biology and Agronomy of Stylosanthes.

Colbran, R. C. (1958). Studies of plant and soil nematodes. 2. Queensland host records of root knot nematodes (Meloidogyne species). Qld. J. Agric. Sci. 15, 101-136.

Colbran, R. C. (1964). Studies of plant and soil nematodes. 7. Queensland records of the order Tylenchida and the genera Trichodorus and Xiphinema. Qld. J. Agric. Sci. 21, 77-123.

Duke, J. A. (1978). Handbook of legumes of world economic importance. Plenum Press. New York and London. 345 pp.

Grof, B., Schultze-Kraft, R. and Müller, F. (1979). Stylosanthes capitata Vog., some agronomic attributes and resistance to anthracnose (Colletotrichum gloeosporioides Penz.). Trop. Grassl. 13, 28-37.

Hall, T. J. (1980). Attack on the legume Stylosanthes scabra Vog. by Platyomopsis pedicornis F. (Coleoptera: Cerambycidae). J. Aust. ent. Soc. 19, 277-279.

Hopkinson, J. M. and Loch, D. S. (1977). Seed production of stylo in north Queensland. Qld. 103, 116-125.

Humphreys, L. R. (1980). Environmental adaptation of tropical pasture plants. Macmillan: London.

Hutton, E. M. and Grylls, N. E. (1956). Legume "little leaf", a virus disease of subtropical pasture species. Aust. J. Agric. Res. 7, 85-97.

Irwin, J. A. G. and Cameron, D. F. (1978). Two diseases in Stylosanthes spp. caused by Colletotrichum gloeosporioides in Australia, and pathogenic specialization within one of the causal organisms. Aust. J. Agric. Res. 29, 305- 317.

Irwin, J. A. G., Cameron, D. F. and Lenné, J. M. (1982). Responses of Stylosanthes to anthracnose. Symposium - The Biology and Agronomy of Stylosanthes.

Joshi, H. U., Carr, A. J. H., and Jones, D. G. (1967). Effect of clover phyllody virus on nodulation of white clover (Trifolium repens) by Rhizobium trifolii. J. gen. Microbiol. 47, 139-151.

Lenné, J. M. and Sonoda, R. M. (1978 a). Occurrence of Colletotrichum dematium f. sp. truncata on Stylosanthes spp. Plant Dis. Rep. 62, 641-644.

Lenné, J. M. and Sonoda, R. M. (1978 b). Rhizopus stolonifer (Ehr. ex. Fr.) Lind., a seed-borne fungus of Stylosanthes hamata (L.) Taub. in Florida Proc. Soil Crop.Sci. Sco. Florida. 37, 39-42.

Lenné, J. M. (1979). Pathogenicity of Sclerotium rolfsii to Stylosanthes capitata and other tropical forage legumes. Plant Dis. Rep. 63, 739-741.

Lenné, J. M. and Sonoda, R. M. (1979). The occurrence of Colletotrichum spp. on Stylosanthes spp. in Florida and the pathogenicity of Florida and Australian isolates to Stylosanthes spp. Trop. Grassl. 13, 98-105.

Lenné, J. M., Turner, J. W. and Cameron, D. F. (1980). Resistance to diseases and pests of tropical pasture plants. Trop. Grassl. 14, 146-152.

Lenné, J. M. (1981). Reaction of Desmodium species and other tropical pasture legumes to the root-knot nematode Meloidogyne javanica. Trop. Grassl. 15, 17-20.

Lenné, J. M. (1982 a). Anthracnose (C. gloeosporioides) of S. capitata: implications for future disease evaluation of indigenous tropical pasture legumes. Abstract. Phytopathol. 72 (in press).

Lenné, J. M. (1982 b). Control of anthracnose of the tropical pasture legume Stylosanthes capitata by burning. PANS. 28, (in press).

Lenné, J. M. and Sonoda, R. M. (1982). Effect of anthracnose on yield of the tropical forage legume Stylosanthes hamata. Phytopathol. 72, 207-209.

Lenné, J. M., de Alvarez, A. V. and Torres, G. C. (1982). Pathogenic variation among isolates of Colletotrichum gloeosporioides affecting Stylosanthes spp. Abstract. Phytopathol. 72 (in press).

Leppik, E. E. (1970). Gene centers of plants as sources of disease resistance. Ann. Rev. Phytopathol. 8, 323-344.

Maraite, H. (1981). L'anthracnose du Stylosanthes en Afrique - situation et strategies de lutte. Report of mission to Burundi, Zaire and the Ivory Coast - Administration de la cooperation au Developpment, Belgium, 1981.

Molhenbrock, R. H. (1957). A revision of the genus Stylosanthes. Ann. Mo. Bot. Gard. 44: 299-355.

O'Brien, R. G. and Pont, W. (1977). Diseases of Stylosanthes in Queensland. Qld. Agric. Jour. 103, 126-128.

Rogers, C. E., Thompson, T. E. and Zimmer, D. E. (1978). Rhizopus head rot of sunflower - etiology and severity in the southern plains. Plant Dis. Rep. 62, 769-771.

Schmidt, R. A. (1978). Diseases in forest ecosystems: the importance of functional diversity. In: "Plant Disease: An Advanced Treatise". Ed. J. G. Horsfall and E. B. Cowling. Vol. 2 pp. 287-315. Academic Press, New York.

Shipton, W. A. (1979). Colletotrichum dematium and C. gloeosporioides on Stylosanthes. Aust. Plant Pathol. Soc. Newsl. 8, 45-46.

Simmonds, J. H. (1966). Host index of plant diseases in Queensland. Dept. Primary Industries, Brisbane, Qld. p. 49.

Sonoda, R. M. (1974). Diseases of Stylosanthes spp. Ft. Pierce ARC Res. Rept. RL-1974-4. 3 pp.

Sonoda, R. M., Kretschmer, A. E. Jr., and Brolman, J. B. (1974). Colletotrichum leaf-spot and stem canker on Stylosanthes spp. in Florida. Trop. Agric. (Trinidad). 51, 75-79.

Sonoda, R. M. and Brolman, J. B. (1980). Reaction of Stylosanthes hamata (L.) Taub. indigenous to southeast Florida to Colletotrichum gloeosporioides (Penz.) Sacc. Proc. Soil Crop. Sci. Soc. Florida. 39, 88-90.

Thomas, D. (1973). Nitrogen from tropical pasture legumes in the African continent. Herbage Abstracts. 43, 33-39.

Tuley, P. (1968). Stylosanthes gracilis. Herbage Abstracts. 38, 87-94.

Wahl, I., Eshed, N., Segal, A. and Sobel, Z. (1978). Significance of wild relatives of small grains and other wild grasses in cereal powdery mildews. In: "The Powdery Mildews" Ed. D. M. Spencer. pp. 83-100. Academic Press, New York.

Wolfe, M. S., Barrett, J. A. and Jenkins, J. E. E. (1981). The use of cultivar mixtures for disease control. In: "Strategies for control of cereal diseases". Ed. J. F. Jenkyn and R. T. Plumb. pp. 73-80.

Zainun, Wan Nik and Parbery, D. G. (1975). Phoma sorghina, a seed-borne pathogen of Macroptilium and Stylosanthes species. Aust. Plant Pathol. Soc. Newsl. 3, 70.