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Tropical Pasture Pathology: A Pioneering and Challenging Endeavor

More than 60% of the world's agricultural land is suitable only for grazing. An estimated 1,050 million hectares in the tropics and subtropics are available for pastures. Most of these lands are in native grasses of low feeding quality and are marginal for meat production in their current state. The increasing human population in most of the tropics has resulted in the more fertile lands being used for production of crops directly consumed or for living space. Productivity of current and potential pasture lands can be greatly increased if improved pasture cultivars and methodologies are used. The high relative cost of fertilizers, especially nitrogen, has focused interest in developing legume-based pastures for the tropics. Many tropical legume and grass species grow well on these currently marginal lands.

The Recent Evolution of Tropical Pasture Science

Compared with crop science, pasture science is a new endeavor. Research in tropical pasture science has been necessarily diffuse because of the many species, environments, and systems involved. The effort to improve pastures in the tropics is a relatively recent phenomenon. Prior to the mid-1950s, little research had been done on tropical pasture improvement. Most early studies were of an observational nature. The advantages of pastures based on legumes for the tropics were not well documented until the 1960s. In recent years, considerable progress has been made in developing tropical legumes for use in mixtures with grasses to increase production.

Reviews of the "domestication" of legumes belonging to the genera *Centrosema, Desmodium*, and *Stylosanthes* (4) tell remarkably similar stories. In each case, only a few genotypes of each genus were tested before those found agronomically acceptable were made commercially available. Little or no effort was made to explore the extent of variation available within each genus. Often with expanded use of these early cultivars, significant limitations to their productivity were found, especially when they were planted in locations away from where they had been selected. Often and increasingly, these limitations included susceptibility to plant diseases.

Pasture Improvement

A practical definition of pasture improvement in the tropics is "the introduction and successful management of permanent legume species in mixed swards with grasses." Improvement ranges from introducing a legume into a native grass pasture to completely replacing the existing vegetation with improved grasses and legumes (Fig. 1). The more extensive the changeover from native to improved pastures, generally the more effort and inputs are required.

Pasture legumes have several valuable functions. They can increase soil nitrogen by fixing it from the air, using it for their own growth and for that of associated grasses or subsequent crops. They supply a higher quality of herbage for grazing or conservation than is usually available with grasses alone; they can ensure a more continuous supply of forage through the year than is possible from grass alone; and they can help prevent soil erosion by year-round ground cover. The primary criteria that determine success for a potential pasture plant are animal performance and ability to persist, preferably under a wide range of climatic and management conditions.

Tropical Pasture Species

Food crops have been domesticated, cultivated, and selected for many thousands of years. Tropical pasture plants, however, have been cultivated for only 50 years, and their genetic resources are not land races but, rather, wild populations of the same species (35). Many genera and species in the Fabaceae and Poaceae have potential as tropical pasture plants. Many of the current as well as potential pasture species are perennial, although some annual legumes and grasses have been used successfully in tropical pastures.

There is a great diversity of perennial legume types—herbaceous plants, creepers, browse shrubs, and trees. Grasses useful for pasture are common, often dominant, constituents of natural grassland communities. Many are polymorphic, offering great scope for further selection from natural populations. Tropical pasture grasses and legumes are not as well defined botanically as those used in temperate pastures. Until recently, they were considered taxonomic nightmares (7).

Most of the legume genera that have proved value for tropical pastures are native to the American tropics. These include *Aeschynomene, Arachis, Centrosema, Desmodium* (some species), *Leucaena, Macroptilium*, and *Stylosanthes* (Table 1) (35). Notable exceptions include some species of *Desmodium* and *Pueraria* from Asia and of *Lablab* and *Neonotonia* from East Africa. Some species evolved on infertile acid oxisols and ultisols and are adapted to the weathered, leached soils that are readily available for pastures in the tropics.

The most important tropical pasture grasses include species of *Andropogon, Axonopus, Brachiaria, Cenchrus, Chloris, Cynodon, Digitaria, Echinochloa, Eragrostis, Hemarthria, Hyparrhenia, Melinis, Panicum, Paspalum, Pennisetum, Setaria, Sorghum*, and *Urochloa* (Table 1) (7). These genera originated in savanna

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regions and evolved in the presence of herbivores. Most originated in Africa, where the great herbivore-grass ecosystems evolved.

Importance of Diseases

Until the mid-1970s, information on diseases of tropical pasture plants was generally confined to records in host disease lists. Pathogens were commonly identified only to genus. Insufficient taxonomic characterization of hosts made identification of pathogen species difficult.

In Australia and Florida, there was initially a notable lack of diseases on introduced tropical American legumes and African grasses. There were no full-time pasture pathologists, and most pasture plant diseases were identified by pathologists working on other crops. However, the lack of recorded diseases may have been due to the absence of pathogens rather than to lack of effort. As more and more propagation materials of these plants (seed, cuttings) were imported, opportunities for importation of pathogens increased. During the late 1970s, epidemics began to occur in areas where plants had been introduced. In Australia, *Colletotrichum gloeosporioides* caused considerable losses in *Stylosanthes humilis*, once the most important pasture legume species in northern Australia. The disease destroyed stands within 3 years and also seriously affected pastures of *S. guianensis* (Fig. 2) (9,11). In Florida, anthracnose caused forage losses of over 50% in otherwise promising accessions of *S. hamata* (24).

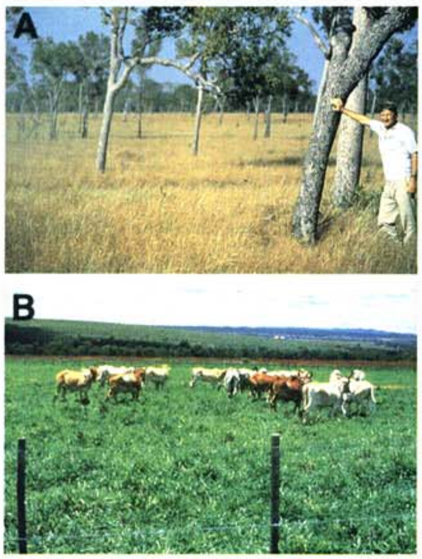

Fig. 1. Pasture improvement involves the introduction and successful management of legume and grass species in mixed swards. (A) An unimproved and (B) an improved tropical pasture of *Brachiaria brizantha* and *Centrosema brasilianum*.

Also during the late 1970s, pasture programs became more active in the areas of origin of tropical pasture plants and their coevolved pathogens, particularly in tropical America. Anthracnose of *Stylosanthes* spp. was recognized as a severe problem that threatened the future of these most promising tropical legumes (20). CIAT's Tropical Pastures Program in the tropical American lowlands responded by initiating a full-time research program on diseases of tropical pasture plants.

Diseases of promising *Centrosema* and *Desmodium* spp. have been identified as major constraints to their persistence and production in pasture ecosystems (18, 22), particularly in the tropical American lowlands (Table 2) (23). Rhizoctonia foliar blight (Fig. 3A), Cylindrocladium leaf spot, and bacteriosis (Fig. 3B) of *Centrosema* spp. and wart (Fig. 3C) and stem gall nematode (Fig. 3D) of *Desmodium* spp. have caused forage losses ranging from 20 to 100%. Rust (*Uromyces appendiculatus*) substantially reduced forage yield, digestibility, and seed yield of *Macroptilium atropurpureum* 'Siratro' in Australia (11). Recent publications review in detail diseases of *Aeschynomene* spp. (30), *Centrosema* spp. (26), *Desmodium* spp. (27), *Macroptilium* spp. (25), and *Stylosanthes* spp. (20) and, where sufficient information is available, discuss their relative importance.

Although many potentially important pathogens have been recorded on tropical pasture grasses (Table 3) (19,21), very limited information on many of these diseases prevents assessment of their relative importance. Diseases of tropical pasture grasses currently regarded as important include Rhynchosporium leaf spot (*R. oryzae*) and rusts (*Puccinia* and *Uredo* spp.) of *Andropogon gayanus*, Cercospora leaf spot and rust (*Uromyces setaria-italicae*) of *Brachiaria* spp. (Fig. 4A), Cercospora leaf spot and smut (*Tilletia ayersii*) of *Panicum maximum* (Fig. 4B), leaf blight of *Paspalum* spp., downy mildews of *Pennisetum, Setaria,* and forage *Sorghum*, and milo disease of forage *Sorghum* (Table 3). Further work is urgently needed on the characterization and assessment of diseases of tropical pasture grasses.

There is generally little information on virus diseases of tropical pasture legumes and grasses.

Diseases in Common with Tropical Crops

Although diseases of many tropical pasture legume and grass species have

Table 1. Origin of the most important species of tropical pasture legume and grass genera[a]

Origin	Genus
Legumes	
Central and South America	*Calopogonium, Cassia, Centrosema, Desmodium, Macroptilium, Stylosanthes*
North and South America	*Aeschynomene*
South America	*Arachis*
Central America	*Leucaena*
Southeast Asia	*Desmodium, Pueraria*
Southern Asia	*Cajanus*
East Africa	*Lablab, Neonotonia*
Grasses	
Tropical Africa	*Cenchrus, Cynodon, Dichanthium, Digitaria, Echinochloa, Eragrostis, Hemarthria, Hyparrhenia, Melinis, Panicum, Pennisetum, Setaria, Urochloa*
East Africa	*Brachiaria, Chloris*
West Africa	*Andropogon*
Asia, Mediterranean, Sudan	*Sorghum* (forage species)
Tropical America	*Axonopus, Paspalum*

[a]Sources: Clayton (7), Williams (35).

Fig. 2. Anthracnose (*Colletotrichum gloeosporioides*), shown affecting *Stylosanthes guianensis*, is the most serious and widespread disease of tropical pasture legumes.

Table 2. Identity and distribution of the most important diseases of tropical pasture legumes[a]

Genus	Disease	Causal agent	Distribution
Aeschynomene	Anthracnose	*Colletotrichum gloeosporioides* *C. truncatum*	Australia, subtropical and tropical America
Centrosema	Cercospora leaf spot	*Cercospora* spp. *Pseudocercospora* spp.	Pantropical
	Cylindrocladium leaf spot	*Cylindrocladium colhounii*	Tropical America
	Rhizoctonia foliar blight	*Rhizoctonia solani* Binucleate *Rhizoctonia* sp.	Pantropical
	Bacteriosis	*Pseudomonas fluorescens* biotype II	Tropical America
Desmodium	Wart/false rust	*Synchytrium desmodii*	Asia, South America
	Stem gall nematode	*Pterotylenchus cecidogenus*	Colombia
	Root-knot nematode	*Meloidogyne* spp.	Pantropical
Macroptilium	Rhizoctonia foliar blight	*R. solani*	Pantropical
	Rust	*Uromyces appendiculatus*	Australia, Caribbean, subtropical and tropical America
Stylosanthes	Anthracnose	*Colletotrichum gloeosporioides* *C. truncatum*	Pantropical

[a]Sources: Lenné (19), Lenné and Calderon (20), Lenné et al (23), Lenné and Sonoda (25), Lenné and Stanton (27), Sonoda and Lenné (30).

received little study, some diseases caused by the same or similar pathogens have been studied on other tropical crops. Information accumulated on pathogen biology, disease epidemiology, and control measures obtained elsewhere, especially on grain legumes and cereals, can benefit research programs on diseases of forages. For example, Rhizoctonia foliar blight or web blight of common bean, cowpea, soybean, and mung bean in the tropics (1) also severely affects *Centrosema* and *Macroptilium* spp. (Table 2). Root-knot nematodes (*Meloidogyne* spp.) find common bean and *Desmodium* spp. receptive hosts. Similarly, leaf blight caused by *Exserohilum turcicum*, an important disease of maize and sorghum (33), also affects several genera of tropical grasses (Table 3). Rhychosporium leaf spot, a potentially important disease of *A. gayanus* (21), is a serious disease of rice in tropical America, while downy mildews of sorghum and millets, caused by *Sclerospora, Sclerophthora*, and *Peronosclerospora* spp., are potentially important diseases of tropical grass genera *Pennisetum, Setaria*, and *Sorghum* (Table 3).

The existence of shared pathogens among pastures and other tropical crops creates problems for both. Strict quarantine measures should be taken in tropical countries dependent on staples such as common bean, cowpea, maize, rice, and millets when exotic pasture germ plasm is being introduced for evaluation or when propagation materials for expanding pastures are brought into a new area. At the same time, pasture production may be jeopardized if diseases spread from indigenous crops to improved pasture cultivars that have no resistance to a pathogen or a race of a pathogen present on these crops. The inoculum produced on these pasture plants will in turn jeopardize the health of other plants. This is currently especially relevant in the infertile acid soil of the eastern plains of Colombia, where improved pastures are expanding rapidly and lines of rice and maize tolerant to acid soil are being developed. Crop and pasture pathologists must work together on diseases common to both crops and pastures in these regions to minimize the occurrence of severe epidemics resulting from buildup of pathogens common to both.

Effect of the Grazing Animal

Research on tropical pastures must consider the impact of the grazing animal, always an important source of heterogeneity in a pasture. Animals usually do not feed on pasture plants in proportion to the relative abundance of plants; instead, they select plant parts and species that are palatable, accessible, and available. Grazing animals sit, lie, scratch, and paw on the pasture as well as walk, run, and jump on it and trample it (31). Pasture heterogeneity results from differential responses to these activities as well as to dispersal of seed by animals (34). Animal activities influence botanical composition, species productivity, and stress responses of plants, all of which can affect disease incidence and severity.

A Complex Ecosystem

Tropical pastures usually are diverse, often but not always perennial, heterogeneous, and complex. The range of tropical pasture species currently used is large. In some cases, diverse genotypes may be used within the same pasture, but often the genotypes within species are few. Free-seeding perennial pasture

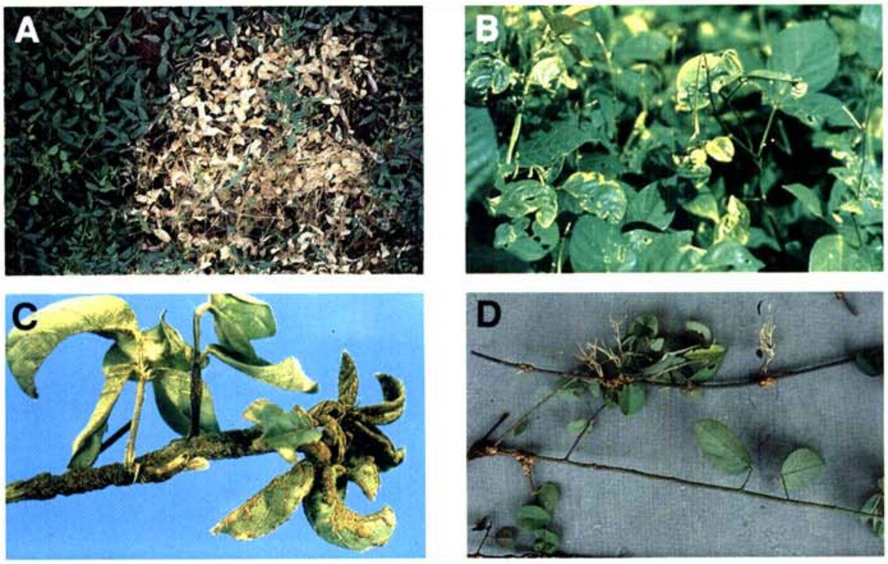

Fig. 3. Important diseases of tropical pasture legumes: (A) Rhizoctonia foliar blight (*Rhizoctonia* spp.) of *Centrosema brasilianum*, (B) bacteriosis (*Pseudomonas fluorescens* biotype II) of *C. acutifolium*, and (C) wart (*Synchytrium desmodii*) and (D) stem gall nematode (*Pterotylenchus cecidogenus*) of *Desmodium ovalifolium*.

plants develop swards that are heterogeneous in age and canopy structure. Most tropical pastures are mixed populations of a grass, a legume, and weeds. The trend toward use of interspecific and intraspecific mixtures of both grasses and legumes creates further diversity and heterogeneity. Host diversity means pathogen diversity at both specific and racial levels. In addition, the diversity of tropical environments, from semiarid savannas to humid tropical woodlands, and the diversity of farming systems, from intensive dual-purpose enterprises to extensive cow-calf operations, create a diversity of epidemiological situations that demand innovative disease evaluation methodologies and management strategies.

Characterization of Diseases

Although basic knowledge of pathogens shared by tropical pastures and other crops is available in some cases, many pathogens of tropical pasture plants were not studied until recently. These include Centrosema mosaic virus of *C. macrocarpum*; stem gall nematode (*Pterotylenchus cecidogenus*) and wart (*Synchytrium desmodii*) of *Desmodium ovalifolium*; rust (*Puccinia stylosanthis*) of *Stylosanthes* spp.; rust (*U. setaria-italicae*) of *Brachiaria humidicola*; and smut (*T. ayersii*) of *P. maximum*, to mention a few. In addition, the absence of growth stage definitions for hosts, disease assessment guides and keys, differential sets to assess pathogenic variation, and definition of race structure complicates characterization of diseases of tropical pasture plants.

Attempts to assess race-specific resistance where little background information on host genetics exists can be confounded with nonspecific resistance that gives a continuum of resistance reactions (2), as found by Miles and Lenné (29) in evaluation of genetic variation within a native *S. guianensis–C. gloeosporioides* host-pathogen population in Colombia. Determination of the virulence structure of tropical pasture pathogens has been described as a "daunting task" because the virulence characteristics of isolates cannot be determined until suitable host lines, each with differing resistance, have been identified (2).

Evaluation of Diseases

Much existing methodology for pasture disease evaluation was developed for temperate grass and legume monocultures. Most of these techniques were modified from those used for evaluating diseases of annual crops. Perennial pastures, such as those that make up much of tropical pastures, are heterogeneous communities of various species of many ages supporting continuous pathogen associations. Diseases are difficult to evaluate using these borrowed techniques (18).

In the past, almost all pasture germ plasm underwent initial evaluation in small monoculture field plots, in the absence of associated species and animals. This approach has been strongly criticized as bearing no relationship to

Table 3. Host range and distribution of important and potentially important pathogens of some tropical pasture grasses[a]

Disease	Causal agent	Host range (genus)	Distribution
Leaf blight	*Pyricularia* spp.[b]	*Brachiaria*	Asia, Pacific
		Panicum	Tropical Africa
		Paspalum	Pantropical
		Pennisetum	Pantropical
		Setaria	Asia, Australia, East Africa
	Exserohilum spp.[c]	*Brachiaria*	India
		Panicum	Australia, Caribbean, Southeast Asia
		Paspalum	Tropical America
		Pennisetum	Australia, India, United States, West Africa
		Setaria	Australia, United States
		Sorghum[d]	Worldwide
Leaf spot	*Rhynchosporium oryzae*	*Andropogon*	Tropical America
	Cercospora fusimaculans	*Brachiaria*	East Africa
		Panicum	Pantropical
Anthracnose	*Colletotrichum graminicola*	*Brachiaria*	Australia, East Africa
		Paspalum	Australia, Caribbean, United States
		Pennisetum	Australia
		Setaria	Australia
		Sorghum	Worldwide
Downy mildew	*Sclerospora graminicola*	*Pennisetum*	India
		Setaria	Asia, United States
	Sclerophthora macrospora	*Pennisetum*	Australia
	Peronosclerospora sorghi	*Sorghum*	East Africa, South America
Milo disease	*Periconia circinata*	*Sorghum*	Australia, United States
Rust	*Puccinia* spp.	*Andropogon*	Tropical Africa
		Paspalum	Pantropical
		Pennisetum	Pantropical
		Setaria	East Africa
	Uredo spp.	*Andropogon*	Tropical Africa
	Uromyces setaria-italicae	*Brachiaria*	Pantropical
		Panicum	Pantropical
		Setaria	Pantropical
Smut	*Sorosporium* spp.	*Andropogon*	West Africa
	Sphacelotheca spp.	*Andropogon*	West Africa
	Tilletia ayersii	*Panicum*	Pantropical
	T. echinosperma	*Setaria*	Tropical Africa, Central and South America
	Tolyposporium penicilliare	*Pennisetum*	Asia, Australia, tropical Africa
	Ustilago spp.	*Andropogon*	West Africa

[a] Sources: Lenné (19), Lenné and Calderon (21).
[b] *P. grisea* and *P. oryzae*; some records refer to *Magnaporthe grisea*.
[c] *E. rostratum* and *E. turcicum*; some records refer to the *Setosphaeria* states.
[d] Forage sorghum only, specifically, *S. arundinaceum* var. *sudanense* (sudangrass) and *S. halepense* (johnsongrass).

the grazed pasture ecosystem (12,32). Associated grasses and legumes and planting of test species within swards are being used increasingly for initial evaluation (Fig. 5). These approaches provide more realistic and natural associations for disease evaluation and facilitate inclusion of animals early in the evaluation process (18).

Various ecological and demographic techniques can be applied to evaluating diseases of heterogeneous perennial pastures (18). Realistic evaluation is essential to assessment of the potential importance of diseases to animal production. Techniques include surveys, transects, fixed or random quadrats, and marked and sampled plants. Surveys can be used to obtain information on disease incidence and distribution on a paddock, site, or regional basis. Surveys usually consist of visual estimates of disease incidence or severity and can be conducted at various time intervals. Caution is necessary, however, when attempting to estimate yield loss based on these subjective data. Transects and quadrats, where disease incidence or severity is more intensively monitored, have been used successfully to evaluate diseases of *Centrosema* spp. in the eastern plains of Colombia (6) and anthracnose of *Stylosanthes* spp. mixtures in northern Australia (Fig. 6) (R. G. Davis, *unpublished*). Results clearly showed that diseases were more severe and their incidence was higher under lower stocking rates and grazing pressures and in dense stands. Marked and sampled plants are often used in plant demography studies. Anthracnose development was evaluated in 3,000 marked plants of *S. guianensis* under grazing in the eastern plains of Colombia from 1985 to 1987. Information was obtained on anthracnose incidence and severity, plant survival, and the effects of other biotic factors (6).

Plants often are affected by more than one disease at a time. Sampling plants and progenies facilitates evaluation of reaction to individual diseases. Plants, randomly sampled from existing swards, were successfully used to evaluate the resistance structure of a white clover population to several foliar diseases in Wales (2) and populations of *Stylosanthes* spp. to anthracnose in South America (17,29).

Diseases affecting seed germination, seedling emergence and survival, and soil seed reserves are important in initial pasture establishment, recruitment of young plants into the adult sward, and persistence of perennial pastures. Evaluating the effect of diseases on these processes will provide information valuable in pasture establishment and maintenance. Quantification of the effects of *S. desmodii* on seedlings of *D. ovalifolium* (28) and *Rhizoctonia* spp. on seedlings of *Centrosema brasilianum* (22) made us more aware of the devastating effects of these diseases on pastures in tropical America.

Assessment of Losses

Economic losses due to diseases in tropical pastures are difficult to measure because the animal, not the plant, is the usual final product (18). Often there will be sufficient forage to maintain high animal production in spite of dry matter losses in pasture plants. Some diseases are more severe near maturity of the plant. Cattle often will feed on diseased plants. Also, by varying stocking rate and pasture utilization, farmers may be able to absorb plant losses due to diseases without affecting pasture production (18). However, diseases that lower plant quantity, quality, and persistence often affect animal production. Determination of yield losses, assessment of quality losses by in vitro chemical analyses, and evaluation of changes in botanical composition are some of the methods used to measure losses in pasture plants.

Management of Diseases

Tropical pastures, with their diverse host-pathogen systems, heterogeneous production systems, and diverse environments, present a unique opportunity for development of imaginative and innovative methods of disease management. Mixtures, both interspecific and intraspecific, are common; heterogeneity is built into the system; and animals can affect disease management. Leath (13) described management of pasture diseases as minimizing disease impact.

As in crops, diseases of tropical pastures can be managed by genetic, cultural, chemical, and biological means. Although each of these methods applies to tropical pastures, genetic and cultural management strategies are the most practical and economical. The low unit-area value of pastures and the necessity for continuous control over long periods render chemical control uneconomical in most cases. As seed treatments, however, chemicals play an important role in pasture establishment. Although the value of biological control is largely unexplored for diseases of tropical pastures, natural control systems occur. One that has been identified is for anthracnose of *Stylosanthes* spp. in humid regions of tropical America (16). Maintenance and possible improvement of natural biological control systems merit attention. There are many low-input pasture

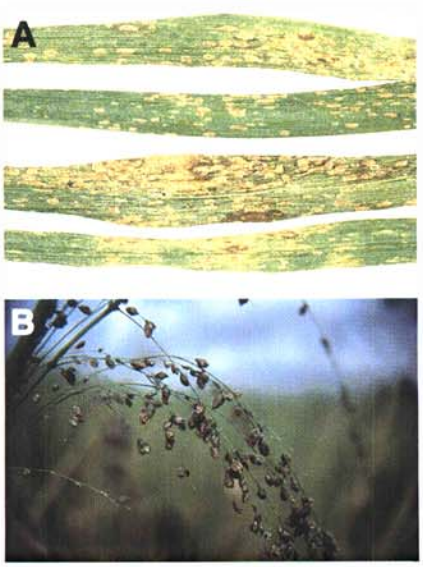

Fig. 4. Two important diseases of tropical pasture grasses: (A) rust (*Uromyces setariae-italicae*) of *Brachiaria humidicola* and (B) smut (*Tilletia ayersii*) of *Panicum maximum*.

Fig. 5. Grasses and legumes are increasingly being interplanted during initial evaluation to provide more realistic and natural disease evaluation and to facilitate inclusion of the animal early in the evaluation process.

Fig. 6. (A) Transects and (B) quadrats are being used successfully to evaluate the incidence and severity of diseases in tropical pastures.

systems where any method of disease control may be uneconomical.

Strategies for disease management to reduce disease losses should be applied before the pasture is actually planted (13). Before planting, practices such as site selection; choice of grasses, legumes, or their association; choice of fertilizer regime; and pretreatments such as precultivation and sanitation can be used to reduce potential for disease losses. At planting, soil preparation and treatment, weed control, seeding rate and depth, seed quality, and seed treatment are practices that may be used to minimize losses. After planting and before grazing commences, fewer alternatives are available. Monitoring seedling emergence, survival, and disease levels are essential to determining whether practices such as roguing (small plantings only), defoliation, and resowing are worth implementing to ensure the best possible pasture establishment.

Resistance is generally regarded as the most economical method for managing diseases of pasture plants (Fig. 7). Almost all current tropical pasture cultivars have been developed by collecting, screening, and commercializing naturally occurring ecotypes (8). An adequate collection of germ plasm of species should be made and evaluated for resistance to common diseases before plant breeding is initiated. In the past, when plant breeding was initiated too early, later collections of wild germ plasm outperformed bred lines.

Fig. 7. Resistance is the most economical method of managing diseases of pastures plants. Agronomically superior genotypes of *Desmodium ovalifolium* (foreground) with resistance to wart and stem gall nematode have been identified in Colombia.

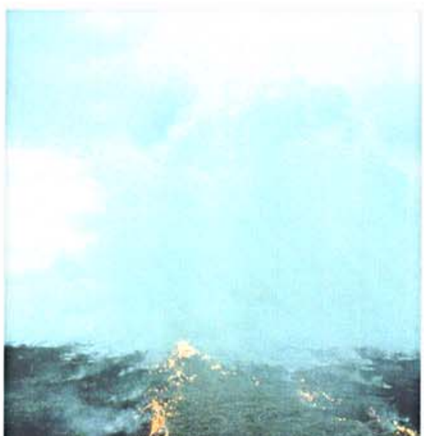

Fig. 8. Sanitation by burning is inexpensive and broadly effective against aboveground pathogens of fire-tolerant tropical pasture plants.

Plant introduction may remain the major source of many pasture cultivars in the near future. Once superior pasture cultivars are established, however, resistance genes from subsequent introductions can be incorporated into them. Whether disease problems can best be overcome by plant introduction or breeding depends on the stage of development of the species (5). At present, productive genotypes from the wild are being selected for use in situations where diseases already occur. An example is *D. ovalifolium* CIAT 13089, which is being tested for use in Colombia. It is an agronomically superior genotype collected from the wild that has high resistance to both wart and stem gall nematode, the most important diseases of this legume in Colombia. Species such as *Stylosanthes scabra* and *S. guianensis*, on the other hand, have been developed for several decades and thousands of introductions have been evaluated. For these, there is an increasing reliance on breeding, biotechnology, and genetic engineering, especially for anthracnose resistance (8).

Being inexpensive and easily incorporated into farming systems, cultural practices such as sanitation, strategic association, and grazing have been used successfully to manage diseases of tropical pastures. Sanitation by burning is inexpensive and broadly effective against aboveground pathogens (Fig. 8). Many tropical pasture plants tolerate fire. For instance, annual and biennial burnings reduced anthracnose of *S. capitata* by 78 and 74%, respectively, in tropical America (15). Strategic association, that is, associating a particular legume with a particular grass to manage a disease of one of the components, was successfully used to reduce damage by root-knot nematodes (*M. javanica*) to *D. ovalifolium* in Colombia (14).

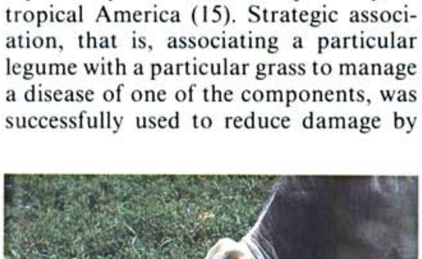

Fig. 9. The grazing animal offers great potential for managing diseases of tropical pasture plants by reducing inoculum buildup and disease development.

Grazing offers great potential for managing diseases of tropical pasture plants. Frequent grazing reduces inoculum buildup and thus disease development (Fig. 9). In the eastern plains of Colombia, high stocking rates were effective in reducing foliar diseases of *Centrosema* spp. without reducing long-term pasture persistence (6).

Prospects

Populations of wild species are patchily distributed through a habitat. Hosts of particular pathogens are interspersed with nonhosts. We are too often ignorant of the defenses that wild species may deploy against pathogens (10). Spatial heterogeneity and genetic heterogeneity for resistance tend to impede the development of disease in populations (3).

Resistance mechanisms operating at the level of the population have great application to tropical perennial pastures. Resistance mechanisms found in undisturbed wild plant populations should be adapted for use in perennial pasture populations that already have diverse constituent species. Population resistance should attract more attention than individual plant resistances in the management of diseases of tropical pastures.

We need to know much more about the recovery of legume-based pastures after serious disease attack. More attention should be given to the demography of plants and their diseases in grazed pastures. We need to understand the effects of diseases not just on individual plants but also on the size and age structure of populations.

Tropical pasture pathology is a young, challenging, and evolving science combining a need for innovative and opportunistic application of relevant knowledge and methods from work done on other crops. The complexity of the perennial pasture—the potential for multiple interactions among pathogens, plants, environmental factors, and the grazing animal—necessitates a multidisciplinary approach. Plant pathologists should work on an integrated team with plant breeders, agronomists, entomologists, plant physiologists, and animal production scientists. There are too few pathologists to handle the immense range of hosts, pathogens, and tropical pasture systems. There is a need to develop widely applicable disease characterization, evaluation, and management methodologies that can be easily modified for specific problems.

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