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Disease: A Constraint to Sorghum Production in Honduras

G. C. Wall, R. A. Frederiksen, Texas A&M University
and D. H. Meckenstock, TAM/INTSORMIL/EAP

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For additional information contact the INTSORMIL Management Entity at:

INTSORMIL
241 Keim Hall
University of Nebraska
Lincoln, Nebraska 68583-0723

Telephone (402) 472-6032
Telex 438087 UN INTPRG LCN
Dialcom 57:CGI025
Fax (402) 472-5136

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G. C. Wall, Texas A&M University

R. A. Frederiksen, Texas A&M University

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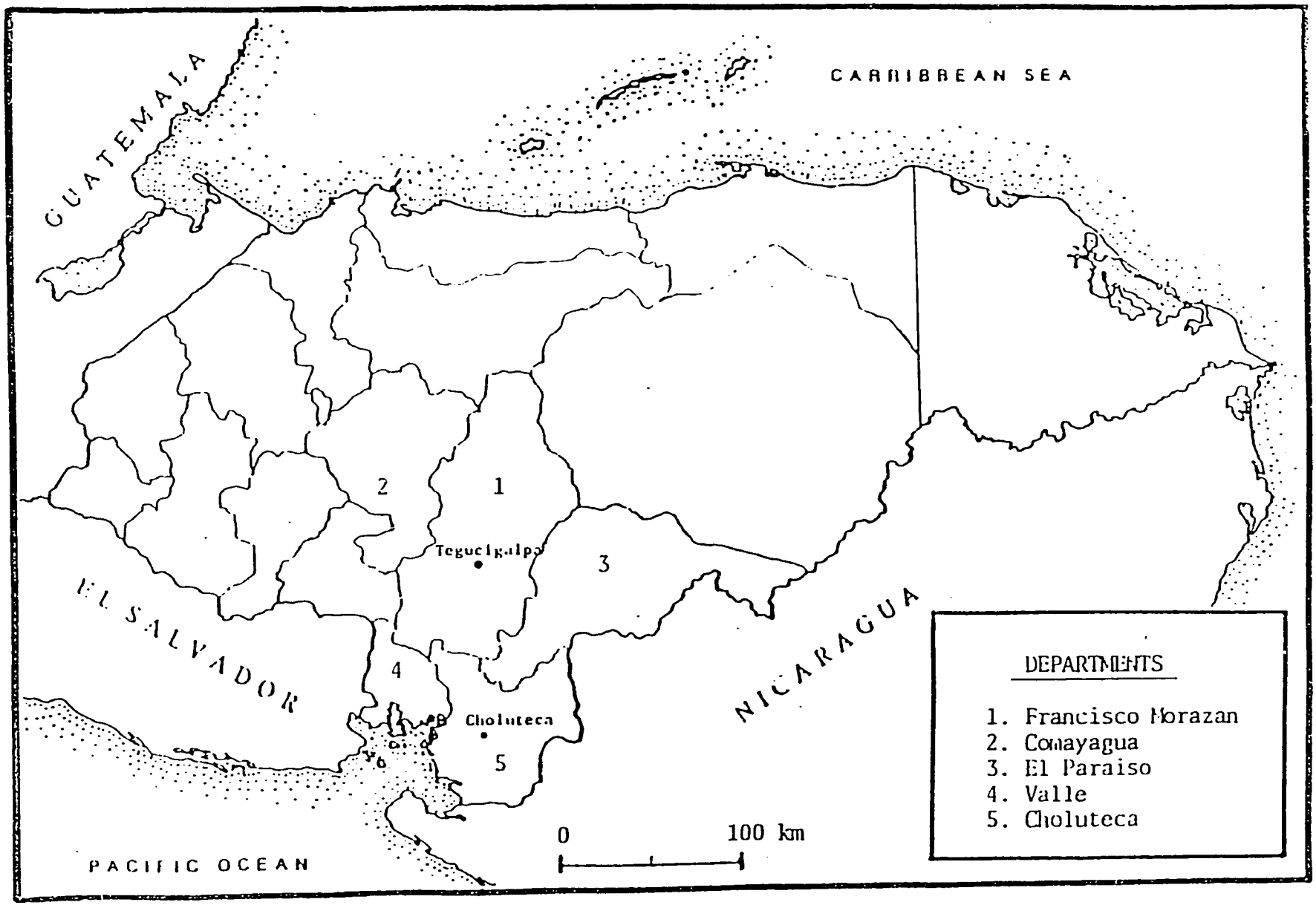
Fig. 1. Map of Honduras.



Abstract

Sorghum is the second most important crop in Honduras, where it supplements maize for tortilla fabrication. In addition, sorghum is fed to poultry, swine, cattle and horses. Ninety three percent of all sorghum production comes from small fields, planted by subsistence farmers. There are few resources available for the production of this crop at the subsistence level. Consequently, the crop develops with no care whatsoever after it is planted. Twenty-one diseases were identified on sorghum growing in the various sorghum-producing regions throughout the country, in surveys carried out between 1983 and 1985.

Data gathered in the surveys served to prioritize these diseases by order of prevalence. Eight of the most important diseases on sorghum were subjected to yield loss studies. It was possible to perform some of these studies under conditions of subsistence farming.

The effect of Acremonium wilt on sorghum production was studied through paired-plant comparisons. Healthy plants produced 50 % more grain than diseased ones. The same technique served to study the effect of maize dwarf mosaic, which caused a 54 % loss in production. Sorghum downy mildew (SDM) was studied by using near- isogenic populations; up to a 44% yield difference in these populations was due to this disease. Gray leaf spot was shown to cause 20% yield loss in a study comparing fungicide-protected and unprotected plots. In a similar test, zonate leaf spot caused a 14% yield reduction.

Disease severity data collected from subsistence farmers' fields was used to develop a mathematical model in another study, with which sorghum yields were estimated at given levels of disease severities. This study included gray leaf spot, oval leaf spot, rust, and covered smut. Yield losses of 15, 5, and 3 % were thus estimated for the first 3 of these diseases, respectively.

Disease severities were also studied under different cropping systems. It was possible to evaluate a number of sorghum accessions planted at various locations throughout Honduras during the time of these studies. Sources of resistance for 6 diseases were identified. These were recommended as breeding stock in the sorghum improvement program under way, co-sponsored by INTSORMIL and the Ministry of Natural Resources of the Honduran government.

Introduction

Sorghum production in Honduras is based mainly on the use of traditional land race cultivars; 93% of all sorghum production is in the hands of resource-poor subsistence farmers (16). The crop is used for feeding poultry, swine, cattle and horses. Also, one third of the total production is used for human consumption (4).

Sorghum serves as a risk-reducing crop. In the semi-arid areas where the maize crop is risky, sorghum offers a more reliable food source. Even though annual rainfall is ca. 1600 mm, the rainy season is normally interrupted by a dry period called "*canicula*". Maize production is often limited by this *canicula*, but not sorghum. In recent years, the government is attempting to increase sorghum production through the creation of a sorghum research program aimed at developing improved cultivars and cultural practices.

In a socio-economic study of sorghum production in Southern Honduras, DeWalt et al. (4) stated that the constraints to sorghum production were many, but diseases were not mentioned. This reflects most subsistence farmers' ignorance concerning plant diseases, which are either blamed on insects and other visible pests, or on superstitious causes.

If sorghum yields are to be increased in Honduras, it is essential to document the importance of sorghum diseases there, to determine the amount of yield loss caused by them, and to develop effective disease control strategies for important diseases. Whether land race cultivars are going to be improved or replaced, effective disease management strategies have to be developed to prevent losses; little is gained by the use of otherwise well-adapted, high-yielding sorghums if they are to succumb to diseases (8).

I. Survey

Sorghum production areas in Honduras (12) include the departments of Choluteca, Valle, Lempira, Francisco Morazan, and Olancho (Fig. 1). Choluteca and Valle are the major sorghum areas. Disease surveys were carried out in all but Lempira and Olancho between 1983 and 1985. Data from the surveys later served to determine what sorghum diseases required yield loss studies.

Methods

Starting in 1983, a general survey was carried out to make identifications of plant pathogens affecting sor-

ghum. These were based on microscopic examination, symptom descriptions, and serological tests where applicable. A more detailed survey was completed in 1985, in which prevalence and severity were recorded. Sample size for the second survey was determined from statistics generated from a pilot survey (2).

Results

From 1983 to 1985, twenty-one sorghum diseases were identified in Honduras (Table 1). Diseases found in all 6 areas were: Acremonium wilt, anthracnose, gray leaf spot, grain molds, ladder spot, leaf blight, loose smut, maize dwarf mosaic, rust, sugarcane mosaic, and zonate leaf spot disease. Some diseases occurred only locally, such as sorghum downy mildew (SDM) in Valle and Choluteca, and maize chlorotic dwarf at one location in El Paraiso. Oval leaf spot was not found un Valle or Francisco Morazan. Other diseases, namely bacterial stripe, charcoal rot, covered smut, head blight, and sheath blight, occurred with less frequency and were observed only in Choluteca, where most of the work was carried out. Head blight was also observed in El Paraiso. Charcoal rot was only seen on agronomically improved cultivars. In the Comayagua area, SDM, ladder spot, gray leaf spot, and rust were the diseases with highest severities and prevalences in 1985. In Francisco Morazan, rust, gray leaf spot, and ladder spot diseases were highest in disease index values (severity x prevalence). In El Paraiso, gray leaf spot and rust diseases were highest. For Valle and Choluteca, the diseases with highest disease index values in 1985 were gray leaf spot and oval leaf spot.

II. Effect of maize dwarf mosaic and Acremonium wilt

Acremonium wilt (AW) is caused by the fungus *Acremonium strictum* W. Gams. It was recently reported and described in the Americas (8). Frederiksen (6) reported AW on various experimental sorghum lines in Choluteca, Honduras, in 1982. This vascular disease can be found wherever sorghum is grown, which is also true for maize dwarf mosaic (MDM), a disease caused by the maize dwarf mosaic virus (MDMV). The host range for MDM includes maize and sorghum; that of AW includes sugarcane additionally. All 3 crops are commonly grown throughout the country.

Methods

Both AW and MDM are diseases that lend themselves well to paired-plant comparisons, due to their systemic nature. To determine the effect of AW on sorghum production in Choluteca, 100 pairs of Acremonium-wilted and healthy plants (BTX 623) were tagged early in the growing season in 1983. Similarly, 100 pairs were tagged in a "maicillo" (land race cultivar). Pairs were selected so that healthy and diseased plants were close to each other in the field. Another 100 pairs of MDMV-infected and healthy maicillos were tagged. However, only 36 pairs of the latter survived complete until harvest time.

Table 1. Sorghum diseases and pathogens identified during the 1983 and 1984 cropping seasons in central and southern Honduras.

Disease	Pathogen	Regions
Acremonium wilt	Acremonium strictum	All
Gray leaf spot	Cercospora sorghi	All
Ladder spot	Cercospora fusimaculans	C, CM, FM
Anthracnose	Colletotrichum graminicola	C, V, EP
Grain molds	Curvularia lunata & Fusarium moniliforme	All
Leaf blight	Exserohilum turcicum	All
Head blight, Pokkah-boeng, & Stem rot	Fusarium moniliforme	All
Zonate leaf spot	Gloeocercospora sorghi	C, CM, EP
Charcoal rot	Macrophomina phaseolina	C
Sorghum downy mildew	Peronsclerospora sorghi	CM, EP
Bacterial stripe	Pseudomonas andropogoni	C
Rust	Puccinia purpurea	C, V, CM, EP
Oval leaf spot	Ramulispora sorghicola	C, V, CM
Sheath blight	Sclerotium rolfsii	C
Covered smut	Sporisorium sorghi	C
Loose smut	Sphacelotheca cruenta	C, V, EP
MCDV	Maize chlorotic dwarf virus	EP
MDMV	Maize dwarf mosaic virus	All
SCMV	Sugarcane mosaic virus	All

Legend: C = Choluteca, V = Valle, CM = Comayagua, EP = El Paraiso, FM = Francisco Morazan.

Results

These comparisons revealed that Acremonium-wilted plants of BTX 623, an elite inbred, suffered a 5% suppression of plant height, had a 3% shorter panicle length, and a 52% shorter panicle exertion. They had 24% fewer kernels, a 16% reduction in 100-kernel weight, and 36% lower yield (Fig. 2). Acremonium- wilted maicillos showed differences only in 3 of the 6 parameters studied. Panicle length was suppressed by 11% and kernel number by 26%, resulting in a yield reduction of 33%. Also MDM affected criollos, suppressing plant height by 9%, panicle length by 13%, kernel number by 43%, 100-kernel weight by 25%, and yield by 52% (Fig. 3).

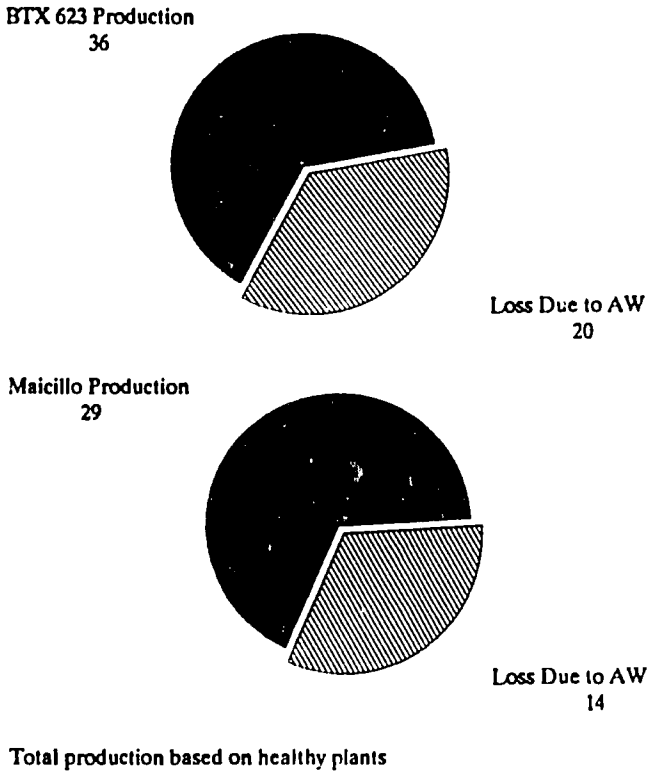


Figure 2. Results of AW Texts
Sorghum grain production (g/plant)

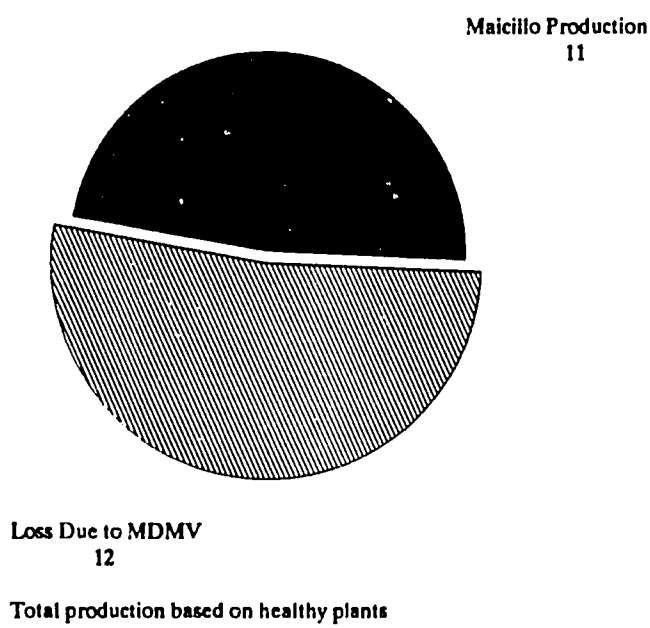


Figure 3. Results of MDMV Tests
Sorghum grain production (g/plant)

III. Comparison of Foliar Disease Severities and Yield Between Fungicide-Protected and Unprotected Sorghum Plots

During the 1983 cropping season, zonate leaf spot was the predominant disease at La Lujosa Experiment Station in Choluteca. This disease is caused by the fungus *Gloeocercospora sorghi*. Although the disease can have a devastating effect on the foliage, its effect on grain yield is unknown. During the 1984 cropping season, gray leaf spot was the predominant disease at the same location. Gray leaf spot (*Cercospora sorghi*) is a serious disease, also causing severe defoliation, and is found throughout Honduras. Its effect on yield is also unknown.

Methods

In 1983, an experiment was designed to study the effect of zonate leaf spot on sorghum yield; comparisons were made between plots protected with fungicide applications and unprotected plots, all planted between spreader rows. Fungicide applications consisted of benomyl plus mancozeb, administered every two weeks. A similar study was done at the same location during the 1984 cropping season on gray leaf spot. Full details are given by Wall (19).

Results

In the 1983 trial, unprotected plots averaged 3.37 ton/ha yield, while those protected from zonate leaf spot with fungicide yielded 3.92 ton/ha. Disease severity was substantially lower in fungicide-treated plots, based on the mathematical summary of disease development (area under the disease progress curve). The disease progress for fungicide-protected plots had a mean value of only one third that of the unprotected plots. The improved cultivars Dorado and Tortillero yielded higher than the land races Coludo and Liberal, although the improved cultivars had higher disease severities.

In 1984, controlling gray leaf spot resulted in a significant yield increase on cultivar Tortillero. With no fungicide protection, this cultivar suffered a 21% loss of leaf area and a 20% loss in yield due to gray leaf spot (Fig. 4).

IV. Effect of foliar diseases on land race cultivars

The vast majority of sorghum growers plant on marginal lands, whereas the Ministry of Agriculture's experiment stations are located in fertile valleys. The authors felt that, in order to generate information relevant to

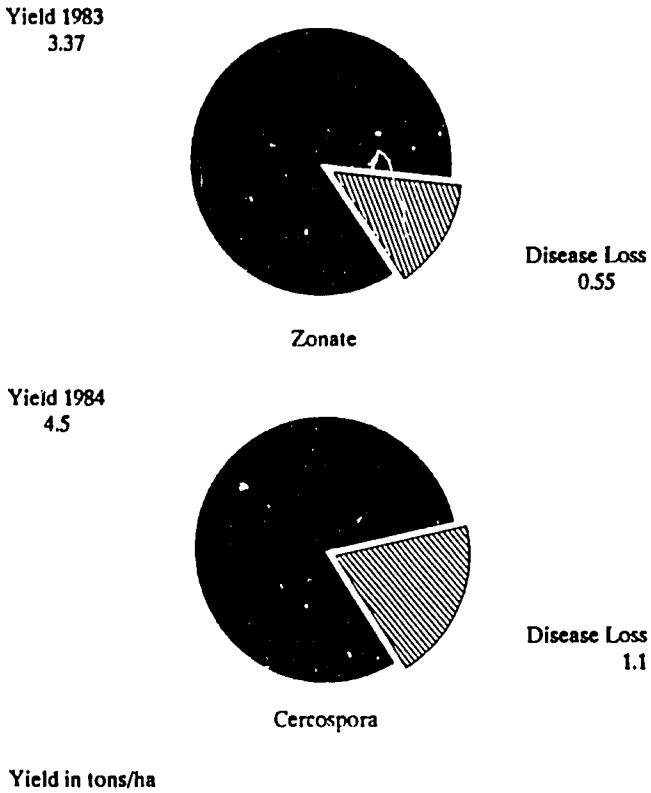


Figure 4. Losses from Foliar Disease Fungicide - protected & unprotected plots.

subsistence sorghum farming (1), some crop loss studies should be carried out in farmers' fields, under subsistence farming conditions.

Methods

Three separate sites were selected for observations on foliar diseases in Southern Honduras because of the differing prevalences of sorghum diseases in farmers' fields At site 1, there was a severe gray leaf spot (*Cercospora sorghi*) epidemic. There was also a moderate amount of covered smut (*Sporisorium sorghi*). The second site was selected because only rust (*Puccinia purpurea*) was observed, although it was at a relatively low severity. At the third site an oval leaf spot epidemic (*Ramulispora sorghicola*) occurred.

Data collected from the foliar disease trials were used to develop empirical mathematical models; these were used to explain variations in yield at each site, and to estimate yield losses due to these diseases. All data from each site were combined, producing a mathematical model based on the principal components of plant height, panicle length, and disease severities. A complete description of this mathematical model is given by Wall, Frederiksen, and Jeger (20). A model of this type can easily be used to estimate yields and losses due to diseases for a variety of purposes, such as research, marketing, planning, modeling, etc.

Results

Results of this study are summarized in Fig. 5. There was a 14.6% difference in estimated yield between plants with the lowest gray leaf spot severity levels (under 20%) and those with 100%. There was an estimated difference of 3.6% in yield between plants with 5% rust severity and those with 25%. A difference of 5.5% in yield was calculated between plants with less than 20% oval spot severity and plants with 100%. Observed versus estimated yields for the general model had a correlation coefficient of 0.792.

V. Effect of Sorghum Downy Mildew on Grain Sorghum Yield

Peronosclerospora sorghi is the fungus that causes sorghum downy mildew (SDM) on grain and forage sorghums. The disease also occurs on johnson grass, various other grasses of the Sorghum species, and on maize. Plants systemically infected by SDM are usually barren. It is generally recognized as one of the most important sorghum diseases (7). SDM was first reported in Honduras in 1974 and has since become well established in Comayagua.

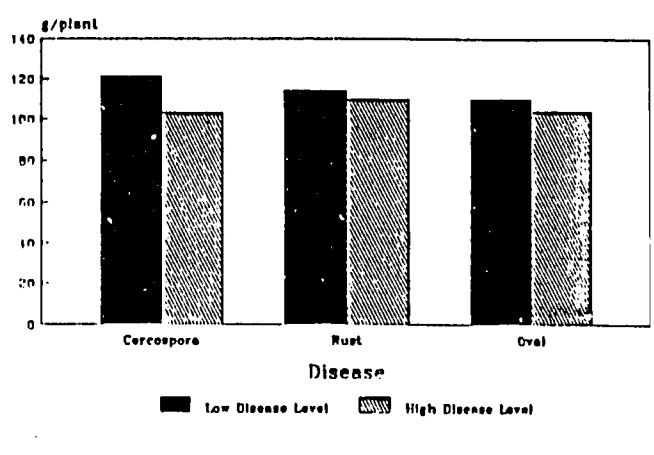


Figure 5. Losses in Farmers' Fields Grain production in land race cultivars.

Methods

Three near-isogenic sorghum populations were planted at Las Playitas Experiment Station in Comayagua, and at La Lujosa Experiment Station in Choluteca (3). These populations differed only in the frequency of SDM-resistant genes they contained. While SDM has become well established in Comayagua, it was not present in Choluteca. Therefore, the same sorghum populations were grown in the absence of SDM, and in the presence of it.

Results

There were no significant differences in yield between populations at Choluteca, in the absence of SDM. In the presence of SDM (Comayagua), the more susceptible population had 43% incidence and yielded 44.3% less than the resistant population, which only had a 3% SDM incidence (Fig.6).

VI. Evaluation of Sorghum Cultivars for Resistance to Various Diseases in Honduras

To the farmer, resistance is the most cost-efficient way of reducing losses due to diseases. Sorghum in Honduras is produced by resource-poor farmers (4, 16). Thus, it is of paramount importance to develop locally adapted sorghum cultivars with high levels of disease resistance.

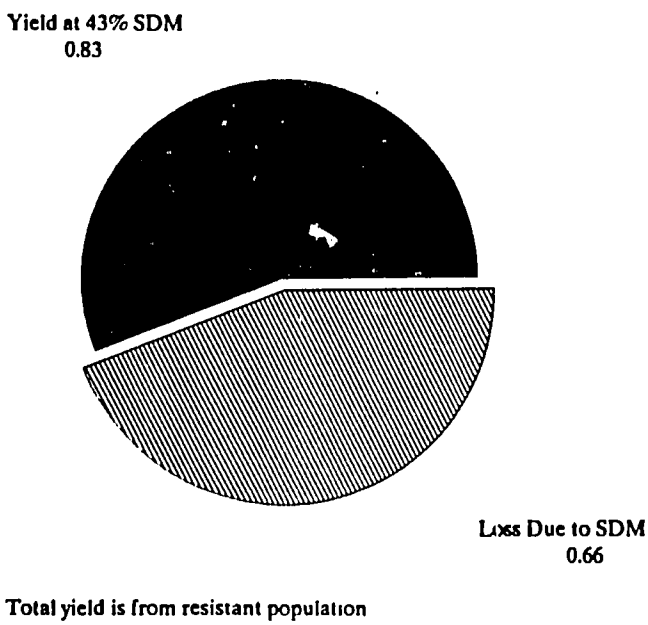


Figure 6. Yield Loss from SDM Sorghum production (ton/ha).

Methods

International disease nurseries are an excellent resource for supplying disease-resistant cultivars. These nurseries are generally designed to contain the most outstanding sources of resistance for a variety of diseases. A number of such disease nurseries are available and several of these were planted at 2 locations in 1983 and 1984 in Honduras; entries were evaluated for resistance to naturally occurring diseases. Other nurseries planted by researchers working with the Honduran sorghum project were also evaluated to identify possible sources of disease resistance.

Results

Several sorghum accessions were identified as resistant to 6 important diseases in Honduras. Sources of resistance were identified for AW, gray leaf spot, ladder spot (*Cercospora fusimaculans*), SDM, zonate leaf spot, and oval leaf spot.

VII. A Study of Sorghum Disease Severities Under Different Cropping Systems

Several cropping systems involving sorghum are found in Honduras and other Tropical American areas (14, 17). The most widely practiced sorghum cropping system in both El Salvador and Honduras is that of sorghum-maize intercropping, accounting for over 90% of sorghum production in these countries. Other systems include sorghum planted alone or intercropped with: maize and beans, beans, cowpeas, "ayote" (*Cucurbita* sp.), sesame and cassava. Sorghum-maize intercropping is popular as a risk- reducing system where there is danger of drought. From a nutritional standpoint, sorghum-bean (*Phaseolus* or *Vigna* spp.) is a desirable intercropping combination (5, 9).

Methods

Micro-climate is an important factor in host-parasite interactions and in epidemic development (21), and may affect disease development differently in the various cropping systems practiced. To study this, disease severities were monitored and compared in sorghum-maize, sorghum-bean, and sorghum- alone cropping systems. Farmers' fields or experiment plots were studied throughout the growing season.

Results

Sorghum-bean intercropping did not affect sorghum plant health in our study. The land races yielded more than improved cultivars in this system. This was not the case in sorghum-alone plots. Overall, foliar diseases were more severe in the early cropping season (primera) than in the later one (postrera). Oval leaf spot was more severe under the sorghum-alone system than under sorghum-maize. Gray leaf spot severity was higher in sorghum-pigeon pea intercropping than in sorghum-alone; however, it was lower in sorghum-maize plots. MDM incidence was higher in sorghum maize plantings (Table 3). Improved cultivars had fewer foliar diseases, but not lower severities, than land races when planted under subsistence farmers' conditions, with little or no fertilization. Yield levels of the farmer, however, were quite low; panicle size was very small.

Conclusions and Recommendations

In the course of these studies, a total of 21 diseases were identified on sorghum growing in different areas throughout Honduras between 1983 and 1985. The importance of diseases varied from one region to another. Cultivars intended for use mainly in one of these regions need only be resistant to the important diseases in that region. Those intended for use in any of the sorghum-producing regions should possess adequate levels of resistance to the five diseases shown to be important in all regions; these are: MDM, gray leaf spot, rust, SDM, and AW (Table 2). Sorghum downy mildew is included in this list, although it was not found in Choluteca, because it has spread to new areas since the studies were begun, it was shown to affect yield drastically, and affects both sorghum and maize.

Survey data indicated which diseases required yield loss studies. These were: Acremonium wilt, maize dwarf mosaic, gray leaf spot, oval leaf spot, rust, covered smut, SDM, and zonate leaf spot. All of these diseases, except for covered smut, were found to suppress yields on sorghum.

Results from the SDM studies confirmed the devastating nature of this disease. The highest incidence, 43%, suppressed yield by 44.3%. Results from this study also show that disease resistance is not necessarily obtained at a cost in yield potential, as is generally believed. Yields in the resistant and susceptible populations did not differ at Choluteca in the absence of SDM.

Table 2. Sorghum entries selected from various international disease nurseries for resistance to several diseases in Honduras from 1983 to 1985.

Cultivar Designation, or Entry	Source or Nursery	Disease Resistance
SC 326-6	ADIN	AC,GR,LD,AN,(AN)
87 CS 447	ADIN	AC,GR,LD,ZN
80 B 2892	ICT	GR,LC,ZN
R 3338	ICT	GR,LD,ZN
82 EON 112	ADIN	AC,SDM,ZN
San Miguel 1	CENTA	GR,LD,OV
SC 748-5	ADIN	GR,ZN,(AN)
77 CS 1	ICT	GR,LD
79 HW 207	ADIN	AC,ZN
TX 435	ADIN	AC,SDM
TX 2794	ADIN	LD,SDM
81 B 6078	ADIN	LD,SDM
Pom pom	Haiti	GR,LD
Las Lajas	RRNN	GR,LD
VG 146	ADIN	GR,SDM
82 BH 5718	ADIN	SDM,ZN
81 EON 69	ADIN	AC,ZN
Brandes	ISAVN	ZN,(AN)

Legend: AC = Acremonium wilt, OV = Oval leaf spot, GR = Gray leaf spot, SDM = Sorghum downy mildew, LD = Ladder spot, ZN = Zonate leaf spot (AN) = Reported resistant to anthracnose elsewhere ADIN, ICT, ISAVN = Texas A&M nurseries, RRNN = Honduras, CENTA = El Salvador.

Yield loss studies on foliar diseases showed as much as 15% losses in farmers' sorghum fields.

In the survey carried out in 1985, the overall mean severity for gray leaf spot was 17%. This amount of disease on cultivar Tortillero suppresses yields by 13.3%. The overall mean for SDM incidence in the same survey produces an 11% yield reduction. In areas where both diseases occur, this implies that yield losses may well be more than 20%, although precise yield loss estimates in such a case would require an actual study of the two diseases simultaneously. In a global perspective, however, yield losses caused by one disease or another have a cumulative effect on national production.

Zonate leaf spot was an important disease in Choluteca. Not only were its severity and prevalence among the highest for that region, but it was also shown to suppress yield by almost 14% on improved and on land race cultivars.

It is unquestionable that sorghum diseases require effective control strategies. In the course of some of our studies, disease severities were enhanced by planting

spreader rows of susceptible materials; conversely, disease severities can be reduced by removing nearby sources of inoculum, such as weed hosts, volunteer plants, and planting a safe distance from older fields of the same crop. Crop rotations are not always practiced because of the small size of the average farms producing sorghum, but they are certainly advisable from the plant health standpoint.

Several questions arose in the course of these studies, which, if addressed, could lead to the development of practical control methods. For instance, plant height and disease severity were correlated in several of the studies. Based on our field observations, we feel that taller plants tend to have lower foliar disease severities. The actual role of plant height and related traits in disease development needs to be clarified. Selection of the right combination of morphological traits in a cultivar could help keep disease levels low.

Plant density and its effect on disease development needs further study. Since it is likely that different cultivars require different population densities for optimum yields, disease and yield levels could be simultaneously studied in density trials on all cultivars.

There is a high degree of heterogeneity for a number of traits in maicillos. This quality gives maicillos the stability that allows them to produce some grain even under quite unfavorable conditions. With respect to disease reaction, heterogeneity in a population can slow down epidemic development (15). As changes are made in maicillos through breeding programs, a degree of heterogeneity should be maintained. The more susceptible genotypes can be eliminated and replaced with new sources of resistance. The resulting plant population would then have the original sources of resistance (if any), plus the new ones, and fewer or no extremely susceptible types.

The intercropping of sorghum with maize seems to reduce the severity of certain foliar diseases; however, MDM had higher incidence under maize-sorghum intercropping than under sorghum monoculture (Table 3). Cultivars of both species intended for use in the former system should have a high degree of resistance to MDMV. Sources of inoculum, vectors, and the disease cycle should be studied to develop effective control strategies.

Sorghum-bean intercropping has been studied and recommended, based on socio-economic and nutritional considerations. We found no phytopathological complications associated with this particular intercropping combination. With social, nutritional, and crop-protection recommendations in agreement, it should prove an advantageous system to promote; Central Americans have practiced intercropping for centuries (10), so adoption should not be a problem.

Table 3. Comparison of disease severity on sorghum and sorghum intercropped with maize.

Location	Variety	Disease	Mean % Severity Sorghum-Maize	Mean % Severity Sorghum
Sta. Irene 1984	Peloton	Oval	15.6	29.7
		Gray	5.0	5.0
		MDM	7.6	1.7
		Zonate	2.0	5.5
San Francisco 1984	Gigante	Oval	10.0	15.1
		Gray	6.8	7.1
		MDM	25.0	5.0

Legend: Oval = Oval leaf sport
Zonate = Zonate leaf spot
Gray = Gray leaf spot
MDM = Maize dwarf mosaic, in % incidence

Improved cultivars had fewer disease problems than land race cultivars when planted in the late season, or postrera. But in various other experiments of this study land race cultivars had lower disease severities than improved cultivars. Improved cultivars had no AW and oval leaf spot incidence, while land race cultivars did. In the case of AW, it is likely that among the improved cultivars in use resistance is the rule rather than the exception. Apparently, land race cultivars have a lower level of resistance to this disease; breeding programs should incorporate AW resistance into future maicillo releases.

In the experimental plots mentioned above, plant densities were higher than in farmers' fields surveyed, and fertilizer application was almost certainly higher as well. Those farmers who will eventually adopt the improved varieties and replace the land races they now use, will have to plant at higher densities and apply fertilizer. Otherwise, their yields will not be high enough to replace the maicillos. Under such conditions, as in the experimental plots, improved cultivars will have more disease problems with gray and zonate leaf spots than the land race cultivars. If a farmer plants year after year in the same field, the use of the more susceptible materials may eventually lead to increased initial inoculum levels. With favorable conditions, this could lead to serious epidemics.

In the case of oval leaf spot, it was not possible to test the reaction of improved cultivars to this disease, so it is not known if they possess adequate levels of resistance, or if the absence of this disease in the improved cultivars sampled in the survey was due to other reasons. However, 2 of 16 land race cultivars tested were resistant to oval leaf spot (Table 4). Until other resistant materials are identified, these can be used in areas where oval leaf spot is likey to be detrimental to production.

Table 4. Sorghum land race cultivars resistant to oval leaf sport at Santa Irene, Choluteca, in 1984.

Cultivar	Source	Mean % Severity
San Miguel 1	CENTA	3.04
MC-3	RRNN	5.46

Legend: CENTA = El Salvador
RRNN = Honduras

Currently, it is feasible to grow land race cultivars, improved varieties or hybrids already released, which possess disease resistance, as a means of reducing losses. For areas with SDM, for instance. the hybrid Catracho and the improved varieties Sureno and Dorado can be recommended; the maicillos MC-97, MC- 117, MC-122, and MC-136 could also be recommended for those farmers who prefer to plant the maicillos, particularly in sorghum-maize intercropping.

The sorghum accessions that were resistant to SDM in Comayagua should be evaluated for their reaction to downy mildew in El Paraiso. Two isolates of *Peronosclerospora sorghi*, from Comayagua and from El Paraiso, were shown to have differing virulence (13). Therefore, it is important that SDM resistance screening in Honduras be carried out in both Comayagua and El Paraiso. When sources of resistance at both locations are identified, they can be used to incorporate resistance into future releases, whether improved varieties and hybrids or land races. One could also use sources of resistance identified elsewhere, such as any of the 10 cultivars found resistant to isolates from different parts of the world (13). However, those sorghum materials already adapted to climatic conditions in Honduras would be the most desirable sources of resistance.

Ideally, different sources of resistance should be used. Relying on resistance from the same genetic background for all varieties and hybrids must be avoided. Several approaches are possible to produce reliable SDM-resistant cultivars. Various sources of resistance could be combined into one cultivar. A different resistance source could be incorporated into each of several cultivars grown in the same region. If heterogeneity is acceptable in a cultivar, as it is in the case of maicillos, then various sources of disease resistance can be introduced without having to combine these in the same plants.

Cultivars that show disease resistance in a number of locations are likely to be more stable than those showing resistance at one site, but not at another (18). Different specific resistances can also be used in combination (11). The basis for any of these control strategies is to have identified different types of resistance. A lesson to be learned from the past is avoiding the use of only one source of specific resistance. Selection of cultivars to be used as sources of resistance should be based on several trials through time and space, preferably tested in the areas of interest. Stable sources of resistance should als be put into a uniform nursery along with experimental materials. This would allow the constant monitoring of these elite resistant sources, while at the same time allowing direct comparisons of the experimental materials with the elite lines. Cultivars with resistance to more than one disease should prove valuable in saving breeding time, particularly those that are also well adapted to climatic conditions in Honduras.

The fact that two resistance sources have different origins is no guarantee that they are truly different. Mechanisms of resistance constitute a better criterion for selecting actually different sources of resistance. There are differences, for example, in the age at which SDM resistance is expressed (13).

There are other measures available for control of SDM; seed treatment with metalaxyl is effective in protecting seedlings from becoming infected, and in preventing the seedborne distribution of the disease. Processed seed should be treated with metalaxyl because seed treatment is easily done in processing plants. It would be more expensive to have seed treatment at the farm level, because the cost of the chemical and of the application would probably be much higher on a unit basis.

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