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Microbial Diseases Affecting Henequen (*Agave fourcroydes* Lem.) in Yucatan, Mexico

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Abstract.
Quijano-Ramayo, A., Herrera-Herrera, J.L., Canul-Salazar, M. and Robert, M.L. 2002. Microbial diseases affecting henequen (*Agave fourcroydes* Lem.) in Yucatan, Mexico. Revista Mexicana de Fitopatología 20:18-23.
The pattern of diseases produced by phytopathogens in some areas of cultivation are changing drastically due, among other causes, to new market trends that induce changes in the agricultural practices, and the introduction of new crops. Monitoring these changes is important in order to take appropriate and timely actions to prevent disease dispersal. A dramatic difference was observed between fungal diseases and one probable bacterial disease of *Agave fourcroydes*. anthracnose leaf spot was present in 1.6% out of the total plants monitored throughout the year at Telchac Pueblo, Yobain and Dzidzantunall, state of Yucatan, Mexico; while pole dry rot and apex dry rot were in 2.5 and 1.2% respectively. In contrast, leaf dry tip (LDT) was detected in all the plantations studied, affecting 42% of the total plants at all locations. LDT also affects fibre yield severely and it is therefore the most serious disease in the area. In this paper, we report the phytopathological status of henequen plantations in the state of Yucatan and discuss the serious threat to productivity posed by the high incidence of LDT disease.

Additional keywords: Leaf dry tip, *Erwinia* spp., *Colletotrichum* spp., *Cercospora* spp., *Fusarium* spp., Yucatan.

Resumen. El comportamiento de las enfermedades producidas por fitopatógenos está cambiando drásticamente en algunas áreas de cultivo, debido, entre otras causas, a las nuevas tendencias de mercado que inducen cambios en las prácticas agrícolas y a la introducción de nuevos cultivos. El monitoreo de estos cambios es importante para tomar las acciones adecuadas a tiempo, con el objetivo de prevenir la dispersión de las enfermedades. Una diferencia dramática se observó entre las enfermedades fungosas y una probable enfermedad bacteriana de *Agave fourcroydes*. La mancha antracnótica de la hoja estuvo presente en el 1.6% del total de las plantas monitoreadas durante el año en Telchac Pueblo, Yobaín y Dzidzantúnall, Yucatán, México; mientras que la secadera del varejón y la pudrición del cogollo se presentaron en el 2.5 y 1.2%, respectivamente. En contraste, la punta seca de la hoja (PSH) se detectó en todas las plantaciones estudiadas afectando el 42% del total de las plantas en todas las localidades. PSH también afecta severamente el rendimiento de fibra lo que la constituye como la enfermedad más seria en el área. En este trabajo, se reporta el estado fitopatológico de las plantaciones de henequén en Yucatán y se discute la seria amenaza a la productividad planteada por la alta incidencia de la PSH.

Palabras clave adicionales: Punta seca de la hoja, *Erwinia* spp., *Colletotrichum* spp., *Cercospora* spp., *Fusarium* spp., Yucatan.

Henequen (*Agave fourcroydes* Lem.), is a species of great socioeconomic importance in the State of Yucatan, Mexico, where it is cultivated for its hard fibre which is used for the production of carpets, ropes, agricultural twine and bags (Rivero, 1985). Currently, the crop occupies an area of approximately 50,000 ha with an average production of 25,000 tons per year (Eastmond *et al*., 2000). The recent reprivatization of the industry and changes in the international markets for hard fibres (FAO, 2000) are stimulating the plantation in new areas and generating a demand for high yielding and healthy planting materials. Henequen is a perennial crop which is cultivated over a period of 15 to 20 years under climatic conditions of high temperature and humidity that favour the development of microbial pathogens; however, there are very few studies on the phytosanitary status of plantations. In a study carried out between 1981 and 1987 (Barrera and Diaz-Plaza, 1993) six types of microbial infections were detected. Three of them were reported to be produced by fungal pathogens: anthracnotic leaf spot (*Colletotrichum* sp.); pole dry rot (*Cercospora* sp.), and apex dry rot (*Fusarium* sp.); one of them, leaf cork spot is of unknown etiology, and two more are mentioned as being of bacterial origin; leaf concentric spot (*Erwinia* sp.) and leaf dry tip (LDT) (*Erwinia* sp.). These studies, however, were not continued and the henequen region of Yucatan has suffered important changes due to the reduction of the cultivated area

and the introduction of new crops, such as papaya, citrus fruit and vegetables. Recently, a new disease of unknown etiology was detected, that produces a soft rot on the tip of the stem, similar to the "bole rot" reported in East Africa (Tanganyika Sisal Grower's Association, 1965). New nurseries and plantations of micropropagated materials have been established in Yucatan to contribute to the estimated deficit of 10,000 tons of fibre per year (Eastmond *et al.*, 2000). The objectives of this study were: to determine the incidence of the main biotic diseases that affect henequen production, and the severity of LDT infection in relation to the amount of extractable fibre in four henequen producing areas in Yucatan, Mexico.

MATERIALS AND METHODS

Area of study, sample size and determination of disease incidence. In order to evaluate the phytopathological status of the henequen area, four locations were included in the study: Telchac Pueblo, Yobain and Dzidzantun, all located some 14 km from the North coast of the peninsula, and Tixpeual situated in the center of the henequen area, about 45 km South of the previous sites (Fig. 1). Normal management may include the application of herbicides, but not of fungicides. At each location, commercial plantations at three different stages of development were chosen for evaluation: stage I, consisted of four to five year old plants that had not yet been harvested; stage II, plantations in full production with eight to ten year old plants, and stage III, old plantations (more than fifteen years) with inflorescences already developing. The samples that were evaluated consisted of six replicates of fifty plants, making a total of three hundred plants for each developmental stage, at each site. Replicates were selected randomly. Since the symptoms produced by each disease are easily identifiable (Barrera and Díaz-Plaza, 1993), visual monthly observations were carried out during a whole year, from january to december, 2000, at all the locations. The incidence of each disease was established as the percentage of plants presenting the corresponding symptoms in each sample.

Severity of leaf dry tip disease. The severity of leaf dry tip (LDT) has two components that should be taken into consideration: a) the number of leaves presenting clear symptoms per plant, and b) the size of the lesion from the tip of the leaves downwards. In order to observe the progress of the disease, records were made from the five rosettes of leaves of twenty plants randomly selected from a stage II plantation in Telchac, Pueblo. The youngest leaves, clearly separated from the apex of the stem, were recorded as rosette A, and the successive rosettes were marked as B, C, D and E. The last rosette contained the largest and oldest leaves on the plant.

Fibre damage. In order to determine how much fibre was lost to the disease, the fibre was extracted from healthy

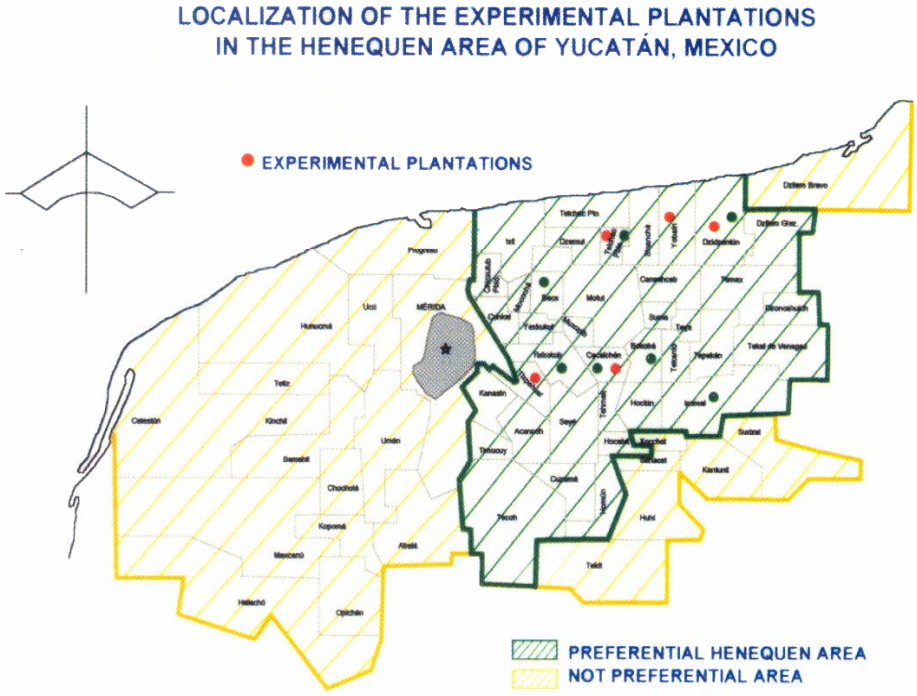

Fig 1. Map of Yucatan, showing the preferential henequen area. Telchac Pueblo, Yobain and Dzidzantun, are located some 14 km from the North coast of the peninsula and Tixpeual is situated in the center of the henequen area, about 45 km South of the previous sites.

commercial leaves (one meter long), and from commercial leaves presenting different size lesions (2.5, 25 and 50 cm). Leaves were individually decorticated using a home-made decorticating machine, driven by an electric motor. Then, they were washed with running water to remove debris and dried by exposure to the sun. Fresh and dry weights were determined using a Sartorius balance.

Statistical analysis. Analysis of variance was performed using Stat graphics 2.4 software. All sets of data were tested for equality variance and normality and transformation was not necessary.

RESULTS

Phytopathological status of henequen plantations. The results of the survey carried out between January and December 2000, at the four sites in the henequen area is shown in Table 1. The diseases previously reported by Diaz-Plaza (1984) were detected, although some of them were still absent in younger plantations (Stage I). A dramatic difference was observed between fungal and bacterial diseases: Anthracnose leaf spot was present in only 1.6% out of the total plants monitored throughout the year in all the locations (regional average), while pole dry rot and apex dry rot were present in 2.5 and 1.2%, respectively. Tixpeual presented by far the highest incidence of those diseases which at some stages, reached 8.6, 9.5 and 4.0%, respectively. In comparison, leaf concentric spot presented a regional incidence of 4.0%, Tixpeual again showed the highest incidence. However, the most serious problem was posed by leaf dry tip (LDT) which was found to have infected 42% of the plants at all locations. In three of the stage II samples, it reached levels of incidence above 60%. Leaf cork spot, of unknown etiology, showed a regional average incidence of 7.4%.

Seasonal variation of disease incidence. Seasonal variation in the incidence of the same diseases throughout the year in Yobain, which is representative of the variation observed in the other three locations (data not presented) is shown in Figure 2. While most of the diseases are present at relatively low incidence throughout the year, LDT had a high incidence and large fluctuations at all stages and locations.

Incidence of LDT. Leaf dry tip appears as a black rot that dries and shrinks leaf tissues (Fig. 3), starting from the tip and progressing downwards covering, in extreme cases, half the length of the leaf. Its incidence at different developmental stages of the plantation is shown in Table 2. At stage I, the disease was already present in Telchac Pueblo and Yobain with incidence of 10.0 and 16.8%, respectively, while in Dzidzantun and Tixpeual it had reached levels of 49.7 and y 43.8%. At stage II, LDT reached incidences above 60% in Telchac Pueblo, Yobain and Dzindzantun, but did not increase in Tixpeual, where it apparently receded a little (32.6%) . At Stage III, incidence levels were inferior in all locations and fluctuated between 32.5 and 44.1%.

Severity of LDT infection. Damage to the tissues included the fibre which appeared as thin brown threads, easily broken and of no use for the manufacture of any kind of product. The amount of fiber lost increased proportionally to the size of the lesion. Figure 4 shows that, even a small lesion (2.5 cm long) is enough to reduce the amount of extractable fiber by 10% and that a 25 cm lesion produces a loss of about 30%

Table 1. Incidence of diseases in commercial plantations of *Agave fourcroydes* in four locations of the henequen area of Yucatan, Mexico.

		Locations																
		Tixpeual				Telchac Pueblo				Yobain				Dzidzantun				
		Developmental Stage of Plantations[y]																
																		Regional
		I	II	III	Avg.	I	II	III	Avg.	I	II	III	Avg.	I	II	III	Avg.	Avg.
Fungal diseases	Anthracnose leaf spot	8.6[z]	2.5	2.0	4.3	0.5	0.0	0.9	0.5	1.5	0.9	1.5	1.3	0.0	0.4	0.6	0.3	1.6
	Pole dry rot	0.0	3.1	9.5	4.2	0.0	4.8	3.8	2.9	0.3	0.6	2.2	1.0	4.5	0.3	0.62	1.8	2.5
	Apex dry rot	0.6	2.6	4.0	2.4	0.0	1.0	1.4	0.8	0.7	1.6	0.6	0.9	1.1	0.2	0.9	0.7	1.2
Disease of unknown etiology	Leaf cork spot	3.9	7.2	12.3	7.8	11.3	11.0	14.3	12.2	3.58	7.5	5.5	5.5	6.5	4.2	1.3	4.0	7.4
Bacterial diseases	Leaf concentric spot	6.0	6.2	5.6	12.6	1.3	1.3	2.3	1.6	1.24	1.4	1.0	1.2	0.8	0.4	0.1	0.4	4.0
	Leaf dry tip	43.8	32.6	44.1	40.1	10.0	62.8	44.0	38.9	16.8	68.4	32.5	39.2	49.0	62.9	37.4	49.7	42.0

[y]Stage I: pre-harvest (4-5 years old); stage II: production (8-12 years old); and stage III: decadence (over 15 years).
[z]Data are the average of 300 plants per stage, monitored monthly from January to December, 2000.

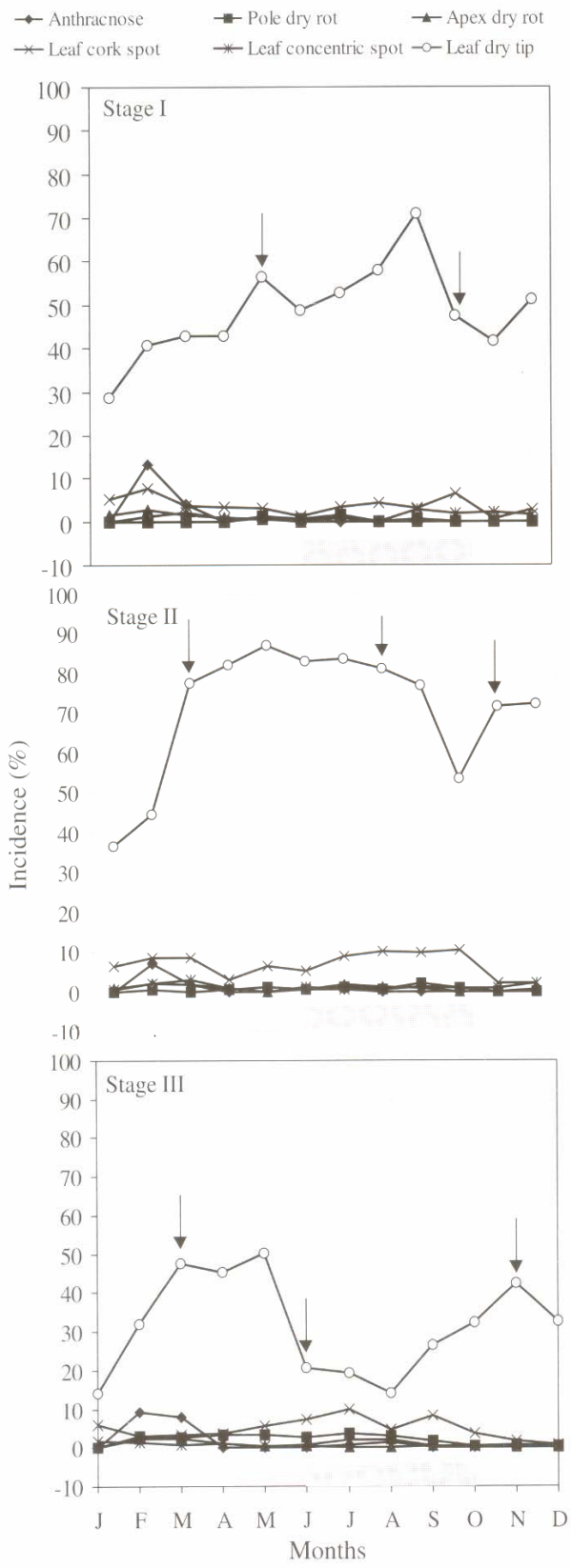

Fig. 2. Seasonal variation of the incidence of diseases in commercial plantations at different stages of development in Yobain, Yucatan, Mexico. Stage I = pre-harvest (4-5 year old plants); Stage II = production (8-12 years); and Stage III = declining (more than 15 years). Data are the average of 300 plants per stage, monitored monthly from January to December 2000. The shade indicates the rainy season and the arrows the month when the leaves were cut.

of the extractable fibre, sufficient to render the leaf useless. Regarding the proportion of infected leaves, Figure 5 shows that the inner rosettes (A and B), formed by the newest leaves, were completely free from the disease. The first infected leaves appeared in the third rosette (C) that showed a mean value of 12% of infected leaves. The outer rosettes (D and E), with the most mature leaves, presented symptoms in about 30% of them. The mean size of lesions in the outer rosettes was 9.5 cm in C, 22.5 in D and 32.5 in E.

DISCUSSION

The presence of diseases caused by microbial organisms seems to be a common occurrence Yucatán's henequen plantations. This is not surprising since henequen is a perennial crop growing in an area where humidity can be as high as 90% during certain periods of the year, and Summer temperatures reach 42°C. The observations presented (Table 1), confirm those previously reported (Diaz-Plaza, 1984; Pérez-Toro, 1950). However, significant changes were observed in the incidence of some of the diseases: Anthracnose, which in 1987 was a serious problem with an incidence of 66%, was now only detected at a low 1.6%. Conversely, LDT increased dramatically from 19 to 49.7% at stage I and from 36 to 68.4% at stage II. There was no clear pattern of incidence of any of the diseases among the different locations, nor was there any distinctive pattern of disease development from stage to stage. This suggests that environmental or management factors probably have a fundamental role in determining the incidence of those diseases. With the exception of Tixpeual, fungal diseases showed a low profile and were present in only 1.8% of all the plants monitored. Bacterial diseases presented a different situation, leaf concentric spot reached 4.0% and LDT a striking 42%. Leaf cork spot, of unknown etiology, showed an intermediate situation, being present in 7.4% of all the plants monitored in spite of its high incidence in Tixpeual. The results reported here indicate that, currently, LDT is the most serious problem in the area, and that it severely affects fibre yield. LDT was detected in all the plantations studied,

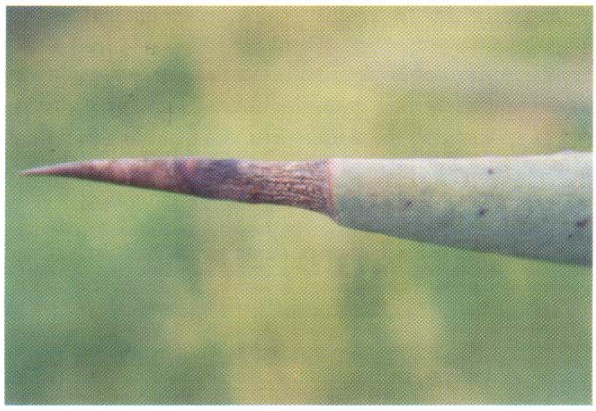

Fig. 3. Typical lesions of leaf dry tip disease, running down from the base of the apical spine.

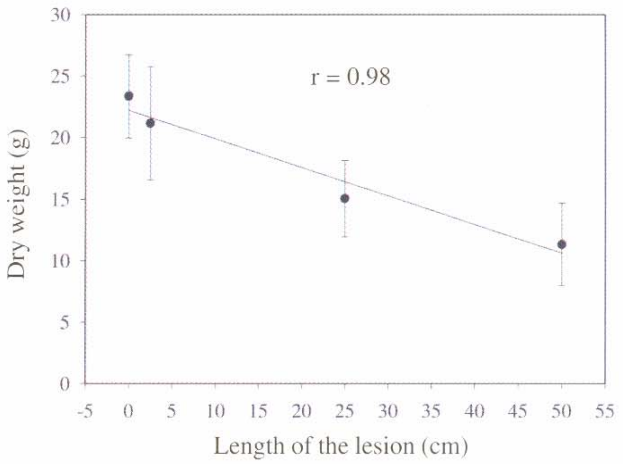

Fig. 4. Fibre extracted from henequen leaves with lesions of different sizes, produced by leaf dry tip.

Table 2. Incidence of leaf dry tip in commercial plantations of *Agave fourcroydes* in four locations of the henequen area of Yucatan. Data are the average of 300 plants per location per stage, monitored monthly from January to December, 2000.

	Plantation Developmental Stage		
Location	I	II	III
Tixpeual	43.8 a[z]	32.6 a	44.1 a
Telchac Pueblo	10.0 b	62.8 b	44.0 a
Yobain	16.8 b	68.4 b	32.5 ab
Dzidzantun	49.7 a	62.9 b	37.4 a

[z]Numbers with the same letter are not significantly different (p = 0.05).

presenting the highest incidence values (between 32.6 and 68.4%) at stage II, in plantations in full production. The increase in LDT incidence observed during the first months of the year (Fig. 2) was unexpected, because it occurs during the dry months; however, it might be explained by the fact that no leaves are harvested during this period and the oldest leaves, showing the most marked symptoms, are left on the plant. The results in Table 2 show that at stage I in Telchac, Pueblo and Yobain, there is a lower incidence of the disease than in Tixpeual and Dzidzantun. This might be due to the different management of the plantations, since in the former, the older leaves that had not reached sufficient size to be harvested were eliminated during the removal of weeds, whereas in the latter this was not the case. However, at stage II, in which all the plantations had approximately the same number of cuttings, the incidence was similar at all sites. To the best of our knowledge, the only epidemiological study of cultivated agaves is the compendium of diseases that affect the East African plantations published in 1965 by The Tanganyika Sisal Growers' Association. They report a disease with similar symptomatology, denominated "leaf tip dieback", of unknown etiology that produces a dry rot in the tip of most mature leaves. The lack of additional information makes the interpretation of results difficult. However, we think that the decrease observed in fungal diseases in Yucatan is linked to the decrease in the cultivated area in the past that produced a reduction in inoculum density and limited spore dissemination (Manners, 1993). This situation, however, did not affect the dispersal of bacterial diseases, which are transmitted usually through handling, and propagation of infected materials. This could be particularly true in the case The results reported here indicate that, currently, LDT is the most serious problem in the area, and that it severely affects fibre yield. LDT was detected in all the plantations studied, presenting the highest incidence values (between 32.6 and 68.4%) at stage II, in

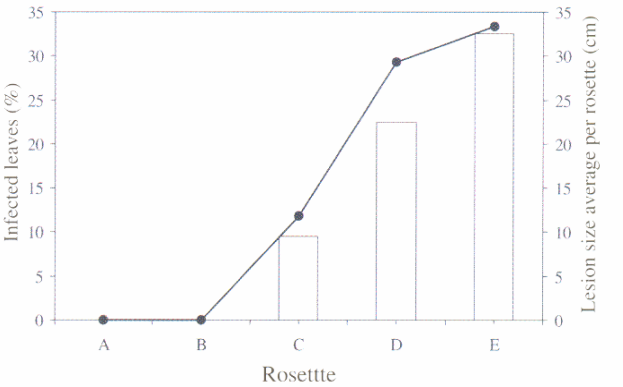

Fig. 5. Severity and distribution of leaf dry tip infection in stage II plants, expressed as the average percent of infected leaves per plant. The results are the mean values of 20 plants from Telchac Pueblo. Rosette A corresponds to the youngest leaves, clearly expanded from the apex, and rosette E to the oldest leaves at the bottom, which are ready for harvesting.

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CONCLUSIONS

It was confirmed the presence of henequen diseases previously reported in all the locations studied, mainly during the second and third developmental stages of the crop. Fungal diseases showed lower incidence values than bacterial diseases. Leaf dry tip is the most important and deleterious bacterial disease found because it has the highest incidence in all locations and at all developmental stages, causing severe losses of extractable fibre. It is necessary to continue the phytopathological studies of henequen, focusing on the etiology of LDT, in order to establish strategies to control both the dispersion and severity of this disease.

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