POSTBLOOM FRUIT DROP OF CITRUS IN BELIZE: I. DISEASE EPIDEMIOLOGY[1] /

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Resumen

La máxima producción de esporas de Colletotrichum gloeosporioides *en agua colectada de árboles de cítricos coincide con la época de floración, la mayor concentración de esporas ocurre durante enero y marzo cuando se presenta el principal periodo de floración y coincide con la mayor caída de frutas proveniente de ese periodo de floración. Entre épocas de floración se encuentran números moderados de conidias pero las inflorescencias no son siempre afectadas. La correlación entre el número de esporas de* Fusarium *y la floración no es tan consistente como en el caso de las esporas de* Colletotrichum.

Se encontró peritecios de Glomerella cingulata *en hojas de cítricos descomponiéndose en el suelo y en menor cantidad en el agua recogida de los árboles; la infección primaria de las inflorescencias se atribuye principalmente a los conidios de* C. gloeosporioides *proveniente de floraciones fuera de ciclo aunque conidios por filoplana de* Colletotrichum *puede también ser un agente casual.*

Introduction

Since its discovery in Belize in 1956/57, postbloom fruit drop disease, associated with a form of *Colletotrichum gloeosporioides* (Penz.) Sacc. (2, 4, 5), has become of increasing economic importance to the citrus growers of Stann Creek Valley, and to the citrus industry of Belize. In this disease, the infection of the blossoms results in abnormal abscission of fruitlets and considerable reduction of the crop can result from severe attacks (4).

Of the two blossoming seasons of citrus in Belize, severe infection occurs only in the main bloom of January to March, from which approximately 95% of the annual crop is normally derived. Fruitset on individual, severely-infected trees may be completely prevented and more than 50% of the annual crop in such groves may be lost. This main flowering season coincides with cool, rather dry weather; the second flowering season usually occurs in June to July when both rainfall and temperature are high, and disease level is usually light to moderate, depending on location. However during the main season, areas subject to high amounts of rainfall are proportionally more badly affected than those receiving very low rainfall. In the Stann Creek area, rainfall increases from a comparatively low level towards the coast, to a high level at the head of the citrus belt (approx. 37 km inland from the coast); disease attacks are generally more severe at such inland locations.

This paper describes experiments conducted in 1971–73 (3) to measure the seasonal abundance of *Colletotrichum* spores in infected groves, in relation to incidence of rainfall and occurrence of blossoms. Such information is considered useful in elucidating the course of the epidemic and in planning control measures.

Materials and methods

Assessment of disease incidence and severity. Postbloom fruit drop disease is recognized by two main symptoms. These consist of (a) initial attacks on the flowers, causing distinct pink to brown spots on the petals which later become completely blighted; (b) this is followed by the second stage when fruitlets abscise leaving the conspicuous enlarged calyces (buttons) of the infected flowers on

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the branches (4). The incidence of the disease can therefore be determined by the presence of infected flowers, or disease buttons which persist on the branches for one year or more. The severity of the disease is roughly proportional to the abundance of infected flowers or to numbers of buttons remaining on the trees. Disease can thus be rated as being absent, light, moderate or heavy according to the absence or increasing abundance of infected flowers on buttons on the branches.

Spore trapping. Four spore traps were placed in each of three groves in the Stann Creek Valley in December 1971. Traps in one grove were serviced until November 1972, and in two groves, until October, 1973. The traps consisted essentially of a rain shield, funnel and container (Figure 1). The rain shield was a piece of heavy-duty aluminum foil supported at the edges by a 25.0 cm frame of wire (2.6 mm diameter); the funnel was a 15.0 cm diameter inverted cone of aluminum foil supported on a two-looped wire frame; the container was 200 or 250 ml glass flask, the larger flask being preferable during periods of high rainfall to prevent overflow. A triangular gutter of aluminum foil was attached across the base of the rain shield which served to exclude direct drifts of rain water from entering the funnel and to collect splashed water from the trees. By means of a long pole secured horizontally within the tree, each trap was suspended at the periphery of a tree canopy, 1.2 – 1.5 m above ground.

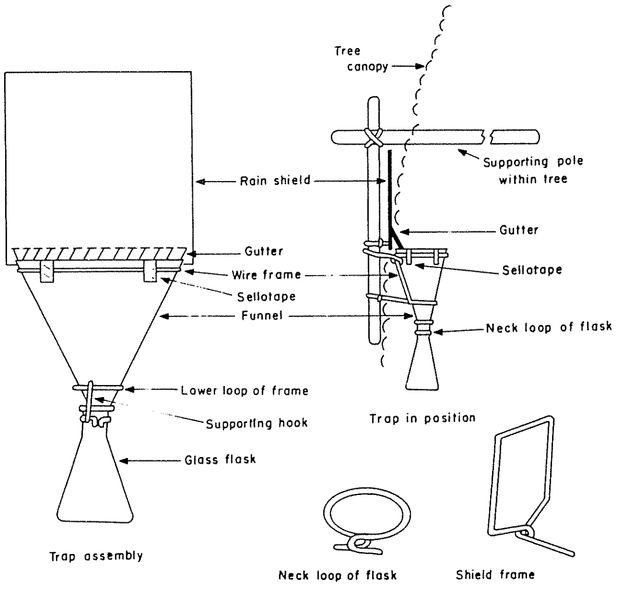

Fig. 1. An apparatus for collecting splash-dispersed spores of *Colletotrichum gloeosporioides* from citrus trees.

Traps were set out once a week and emptied usually on the morning following rainfall during the previous 24 h. At each servicing, observations were made of the state of flush and occurrence of infected flowers. Periods between recorded servicing were not constant as they depended on rainfall producing a minimum of 50 ml total rain water/grove. Volumes below this were not recorded. Water collected in the traps in each grove was bulked and measured. A 150 ml aliquot of the sample was used except where the total volume collected was less than this, when the whole sample was processed. The sample was filtered through a thin layer of absorbent cotton wool to remove coarse debris; a 50 ml aliquot of this was centrifuged for spore assessment, but 45 ml was used where the original sample did not permit more than this. To facilitate rapid identification of spores, a few drops a 0.1% cotton blue-lactophenol stain were added to the filtered water before an aliquot was taken for centrifuging.

The sediment was taken up in the last 4.5 – 7.0 ml (usually 5.0 ml) of the centrifuged aliquot and spore counts were done on two 7/^{u}l drops. Twenty low power (x 60) microscope fields, covering a known area of the coverslip on each drop, were scanned and the average count/drop of concentrate was calculated from this. The concentration of spore/ml of original sample was then calculated.

Field observations. In addition to routine observations on disease levels in various citrus groves in the main citrus belt of the Stann Creek Valley, visits were paid to groves in the Cayo District in the west of Belize and to Corozal District in the north, where decreasing quantities of citrus are also produced. The level of disease incidence, and data on rainfall in those areas were noted.

Both prior to, and during the course of the spore trapping experiments, regular field examination of flowers, dead twigs and leaves, and old buttons were made to discover the presence of any perithecia of *Glomerella cingulata* (Stonem.) Spaulding & Schrenk, the perfect state of *C. gloeosporioides.*

Results

Peaks of spore concentration coincident with the blossoming seasons occurred in all groves (Figure 2). The greatest numbers of spores were present during the main bloom, but conidia were present in moderate numbers between blossoming seasons. In November 1972, few blossoms were recorded in groves A and B and those found were usually uninfected. The sources of the conidia producing the peaks during that month were not evident. There

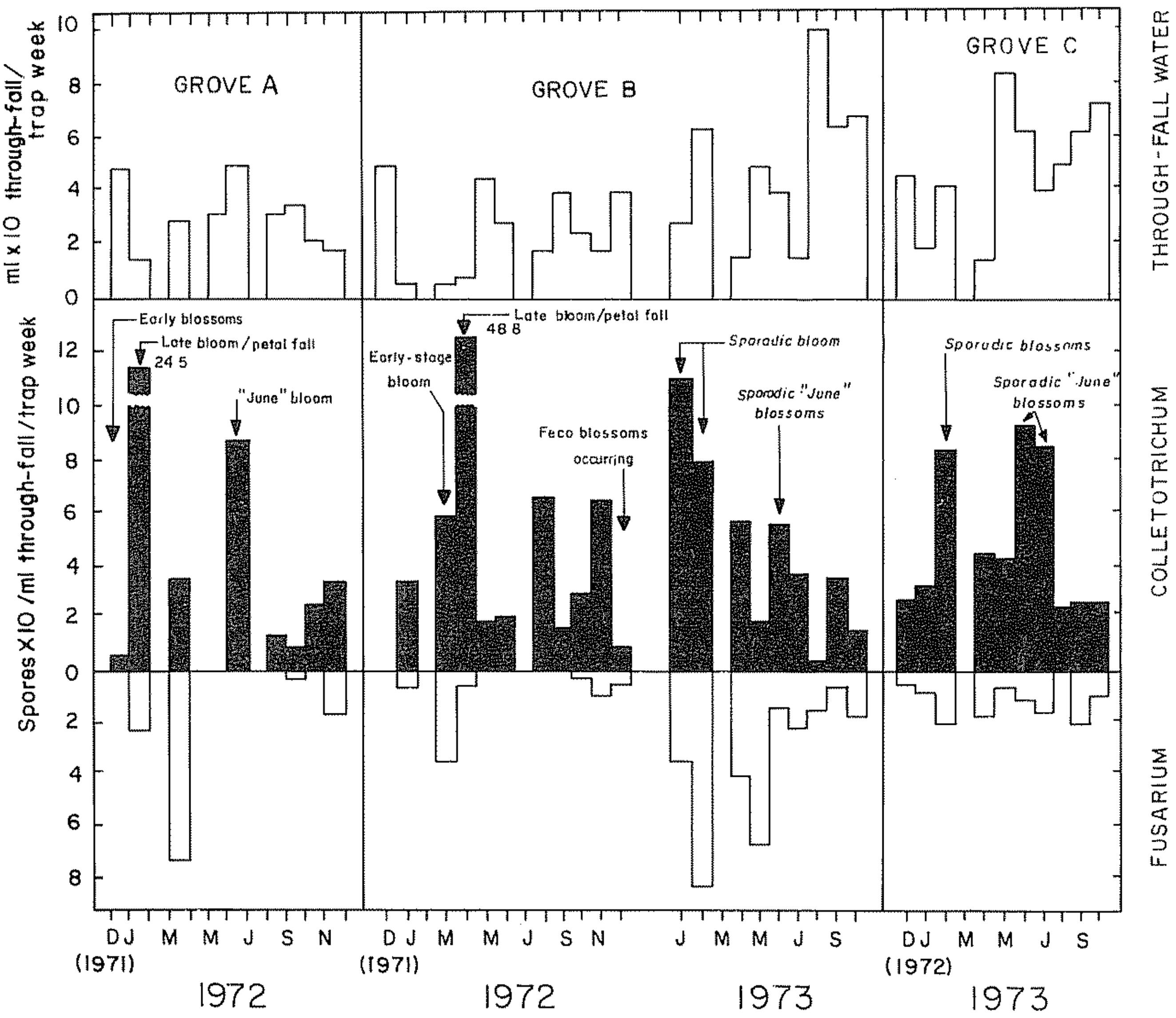

Fig. 2 Relationship between incidence of rainfall, blossoming of trees and occurrence of spores of *Colletotrichum gloeosporioides* and *Fusarium* spp. in three groves of Valencia orange in Belize.

was no peak in grove B in December 1972 during which only a few, uninfected flowers were recorded on test trees, but one peak appeared with the onset of blossoming and of infections in that grove in January and February, 1973. Spores of *Fusarium* spp. were generally much fewer than those of *C. gloeosporioides* except in February 1973, when the two levels roughly coincided (grove B, 1973). Correlation between the number of *Fusarium* spores and occurrence of blossoms were not consistent.

No perithecia of *G. cingulata* were found on petals, old buttons or dead twigs during the experiment, but some were present on dead and decaying leaves on the ground. However, ascospores occurred in the traps in groves A and B during August to November 1972, but not in 1973. The concentration of these was generally proportional to conidial concentrations and, like the latter, inversely proportional to the volume of trapped water (Table 1).

Comparison of rainfall figures for Stann Creek Valley, Cayo and Corozal Districts (Table 2) reveals that rainfall in Stann Creek is much higher than Cayo and Corozal, particularly the latter. This difference in levels of rainfall was found to be reflected in the levels of postbloom fruit drop incidence in the respective districts; whereas the disease was serious in Stann Creek, it was generally of low incidence or moderate severity in Cayo and was not observed in Corozal District. There was no relationship between temperature differences and disease levels.

Table 1. Occurrence of conidia of *Colletotrichum gloeosporioides* and ascospores of *Glomerella cingulata* in rain water from orange trees in two groves in Stann Creek Valley, Belize, in relation to rainfall (1972).

Month	GROVE A Vol. rain water collected (mls)	No. of conidia /ml	No. of ascospores/ml	GROVE B Vol. rain water collected (mls)	No. of conidia /ml	No. of ascospores/ml
16 August	500	0	0	100	1 226	549
4 September	465	0	0	373	136	136
19 September	270	181	45	425	90	45
4 October	100	407	181	165	542	361
19 October	350	32	32	325	64	0
10 November	100	1 903	0	298	65	97

Table 2. Comparative rainfall (1959 – 70) in three districts of Belize, differing in incidence of postbloom fruit drop disease of citrus.

Month	Stann Creek District (High incidence) mm	Cayo District (Moderate incidence) mm	Corozal District (No disease) mm
January	165	117	75
February	86	40	31
March	86	61	21
April	94	68	38
May	152	60	120
June	310	241	193
July	312	146	190
August	295	178	149
September	295	189	241
October	239	141	135
November	219	164	90
December	157	95	60
Total	2 410	1 600	1 343

Discussion

Although field examinations of citrus trees during the experiment failed to reveal the presence of perithecia, the occurrence of ascospores in run-off water shows that they do occur on the trees. The erratic appearance of the ascospores, however, limits their importance as source of primary inoculum for blossom infection; it is suggested that conidia, which occur in fair numbers for most of the year, play an important part in this event. Denham and Waller (1) suggest that these conidia are produced by a phyllophane, low-pathogenic strain of *C. gloeosporioides*. Once infection sets in, there is a rapid build-up of inoculum originating from acervuli on infected flowers and disease spread is maintained by these

Dispersal of spores is facilitated by rain splashes and air currents, and probably also in water droplets from heavy dew (which frequently occurs during the main blossoming season, particularly in groves situated in depressions, and sheltered by wooden hills – conditions which favour high humidity). Dissemination of spores within and between trees may be assisted by insects; since the mature crop is usually harvested during the blossoming season of the succeeding main crop, pickers may carry masses of conidia on their bodies and ladders, particularly when trees are wet.

There was evidence of dilution of spores by increasing amounts of rainfall as observed by Waller (6), in the case of *Colletotrichum coffeanum* Noack on *Coffea arabica* L.

Although it has been noted that areas receiving highest rainfall suffer proportionately higher incidence of disease, the critical rainfall influencing disease severity in the main bloom occurs around the driest portion of the "dry season" when sufficient dispersal, but little washing-off of spores, results

Apart from the important effect of dilution of inoculum by large amounts of through-fall, the low level of disease observed during the warm, high-rainfall period of June to September probably results from (a) the ability of the fungus to germinate well at lower rather than at higher temperatures (4) and (b) the longer duration of condensation forming on flowers in the cooler nights of January to March The areas of higher rainfall lie mainly towards the wooded, hilly western portion of the citrus belt; besides the higher humidity, the occurrence also of higher rainfall in such areas (compared with areas closer to the sea) during the cool dry season, provide adequate facilities for spore dispersal and higher disease incidence.

Infection of trees spreads faster downwards and horizontally than upwards – a pattern consistent with spore dispersal by rain splashes and dew drops; it may spread from a single median branch to severely effect the entire tree within the brief period of one blossoming season (3–4 weeks). From such an infected tree, disease may spread for a distance of five trees along a row (7 6 m tree spacing) in the direction of the prevailing wind, and two trees in the opposite direction; no infection was observed beyond one parallel row (9 1 m apart) on either side of such infected trees Such rapid spread is consistent with wind-assisted spore dispersal and the involvement of pickers

Summary

Peaks in the occurrence of spores of *Colletotrichum gloeosporioides* in run-off water from citrus trees coincided with the blossoming seasons; the greatest numbers of spores occurred in the main bloom period of January to March, during which postbloom fruit drop disease is usually severe. Conidia were present in moderate numbers between blossoming seasons, but off-season blossoms were not always infected. Correlation between numbers of *Fusarium* spores trapped and the occurrence of blossoms was not so consistent as in the case of *Colletotrichum* spores.

Perithecia of *Gomerella cingulata* often occurred on rotting citrus leaves on the ground, but few ascospores were found in run-off water; primary infection of blossoms is attributed mainly to conidia of *C. gloeosporioides* from off-season blossoms, but conidia produced by phylloplane *Colletotrichum* inhabitants may also be involved

Literature cited

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Reseña de libros

BORNEMISZA, E. Introducción a la química de suelos. Washington, D. C.; Secretaria Gral de la OEA. Programa Reg. de Desarrollo Científico y Tecnológico. Serie de Química, Monografía No. 25. 1982. 69 p.

Este trabajo constituye una contribución más a la colección de monografías científicas que sobre temas de física, química, biología y matemática edita el Departamento de Asuntos Científicos y Tecnológicos de la Secretaría General de la OEA, destinada a profesores y alumnos de ciencias de los primeros años de la Universidad.

Resumir en 69 páginas los aspectos más importantes de la química de suelos es una tarea muy difícil. Sin embargo, esta obra constituye una contribución bastante completa y fundamentalmente comprensible. Al final de cada capítulo se ofrece una bibliografía actualizada que permite profundizar cada tema.

El capítulo 1 referido a los componentes inorgánicos del suelo resulta algo complejo para estudiantes universitarios con conocimientos básicos de química (objetivo propuesto por el autor) en la medida que resumir en 16 páginas los minerales primarios y secundarios, así como los procesos de meteorización exige demasiada síntesis en detrimento de la comprensión. Los ejemplos ofrecidos respecto a los suelos en que se presentan los distintos minerales colaboran en parte a subsanar este problema.

El capítulo sobre materia orgánica es claro y conciso; ofrece un resumen de los principales grupos de sustancias orgánicas en el suelo, su importancia y los procesos generales de descomposición, Se destaca la importancia de los complejos organominerales y la necesidad de un estudio más exhaustivo de los mismos.

El capítulo 3 sobre los procesos de adsorción en el suelo ofrece una revisión muy completa de las teorías existentes acerca de este fenómeno y su representación matemática (isotermas de Langmuir y Freundlich; ecuación de BET). El tema del intercambio catiónico ha sido especialmente tratado, incluyendo modelos de representación, ecuaciones de equilibrio y factores que lo afectan.

En el capítulo 4 se considera el rol de los oligoelementos en el suelo (Fe, Mn, Zn, Cu, Cl, B y Mo) ofreciéndose un resumen muy completo acerca del origen de los mismos y de los factores que afectan su disponibilidad.

En general esta monografía presenta una buena introducción a la química de suelos, escrita además en un castellano claro, aspecto normalmente deficiente en las traducciones y libros sobre suelos en nuestra lengua. Resulta particularmente interesante el capítulo sobre los fenómenos de adsorción. No queda claro porque no se ha incluido un breve capítulo sobre macronutrientes, esencialmente P y N, que hubiera contribuido a ofrecer una obra aún más completa.

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