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# Fungal and Bacterial Diseases of Aroids in Costa Rica

Irma G. Laguna, Luis G. Salazar and José F. López



# Fungal and Bacterial Diseases of Aroids:

## *Xanthosoma* spp. and *Colocasia esculenta* (L.) Schott, in Costa Rica

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José F. López

Translation by: **Sue Shannon**

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## INTRODUCTION

Aroids (*Xanthosoma* spp. and *Colocasia esculenta* (L.) Schott) are important as crops principally in the humid tropical lowland areas of the world. Although important at world level, in the Central American isthmus they have not yet received recognition as potential energy sources, animal feed, processed products or as a source of foreign exchange. In several parts of Nort America there exist concentrations of people of Latin American origin who constitute a demand for these products and represent an export market with great growth potential for the countries of the Isthmus.

Cultivation of aroids at a commercial level started approximately 10 years ago in Costa Rica. The species most grown are the white cocoyam (*Xanthosoma sagittifolium* Schott), the violet cocoyams, (*Xanthosoma violaceum*) and also a species of lesser importance (cover photo), taro (*Colocasia esculenta* (L.) Schott (Figure 1)., with its varieties *Colocasia esculenta* (L.) Schott var. *antiquorum* (Schott and Rehder): “eddoe” type, and *Colocasia esculenta* (L.) var. *esculenta*: “dasheen” type. The corms of these species are used for home consumption and for the last 6 or 7 years have been exported to several European countries and the USA.



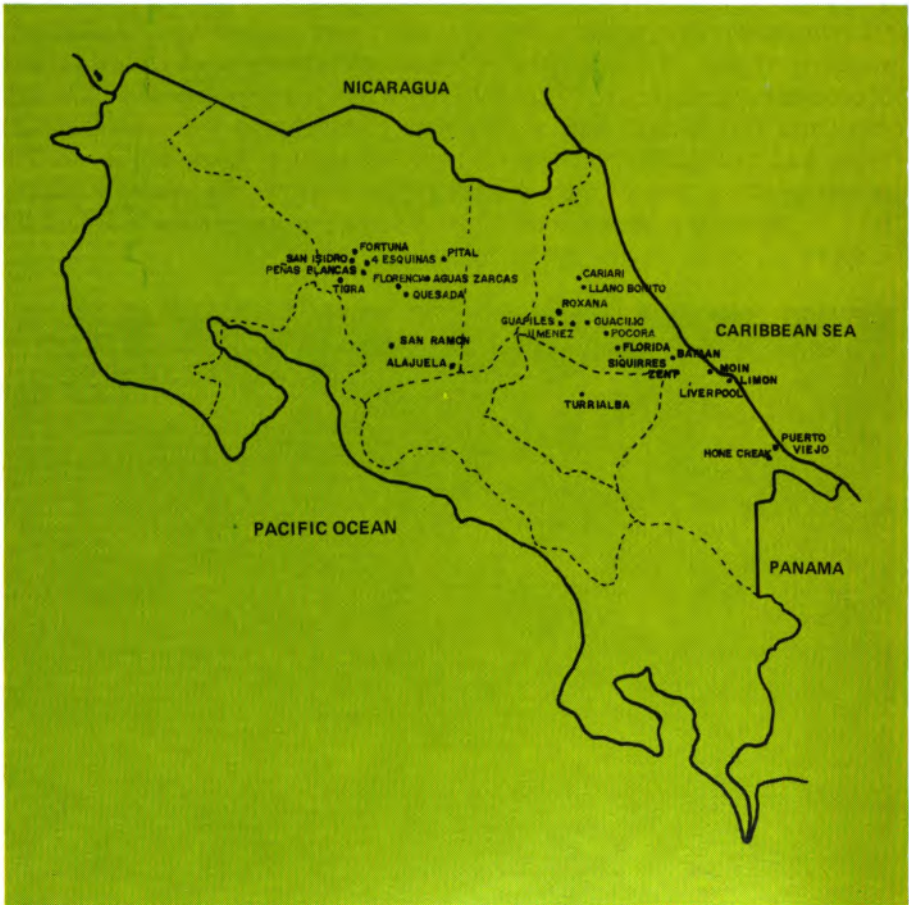
FIGURE 1. Taro (*Colocasia esculenta* (L.) Schott).

As cultivation of these species has intensified, so various diseases have started to limit production. A number of fungal and bacterial infections have been observed in different growing areas of Costa Rica.

This publication describes some of the more important fungal and bacterial diseases that have been found in the aroid-producing regions of Costa Rica (Limón and Alajuela provinces) and in the experimental plots at CATIE, Turrialba, Cartago Province (Map 1). The principal symptoms are described and illustrated with the intention of providing a guide to the identification of the diseases and their causal agents for researchers, students, extension agents and farmers.

The study was carried out in three areas of Costa Rica (Table 1).

The diseases were described in the field and samples collected for identification of the pathogens in the laboratory.



MAP 1. Localities where diseases affecting Aroids in Costa Rica were observed.

Table 1. Areas of study in Costa Rica.

| Study Area                     | Height above sea level (m.) | Mean annual rainfall (mm.) | Mean temp (°C) |
|--------------------------------|-----------------------------|----------------------------|----------------|
| Limón (Atlantic zone)          | 200-700                     | 3000-4000                  | 25-27          |
| San Carlos (Alajuela province) | 65-1000                     | 2500-3000                  | 18-29          |
| Turrialba                      | 600                         | 2600                       | 22.3           |

The pathogens were isolated from diseased tissue, cultured on potato-dextrose agar (PDA), pH 6.5 incubated at 25°C. Subsequently, healthy plants were inoculated in an attempt to provoke the same symptoms under laboratory or greenhouse conditions that had been observed in the field.

Isolated pathogens from field and artificially infected plants were examined under the microscope in PDA. Morphological, culture and pathogenic characteristics were studied to enable identification.

The incidence and distribution of each disease was determined by sampling in the study areas. Figures stated subsequently refer to the mean value obtained for the disease in each plot sampled.



# Foliar Diseases

## DISEASES CAUSED BY FUNGI

### *Leptosphaerulina trifolii* (Rostrup) Petrak

In both mature and young leaves the symptoms of this disease are small necrotic patches, from 0.5 to 2.3 cm. diameter. The shape of this spots is variable, rounded or nearly round, oval or irregular (Figure 2a). They are light brown coloured with a red margin surrounded by a chlorotic halo (Figure 2b). The dead part falls away with time.

The spots can occur singly or in clumps. More than 100 spots on one leaf have been observed during severe attacks, leading to complete necrosis. (Figure 2).

On the upper surface of the spots subepidermal black ascocarps can be seen. These ascocarps are spherical, 130 - 160  $\mu$  across (Figure 2b) with oval asci measuring between 60-90  $\mu$  x 30-40  $\mu$  and 8 muriform hialine ascospores with 3 to 4 tranverse septa and 1-2 longitudinal septa. The ascospores measure 20-35  $\mu$  x 6-9  $\mu$ . The *Leptosphaerulina*

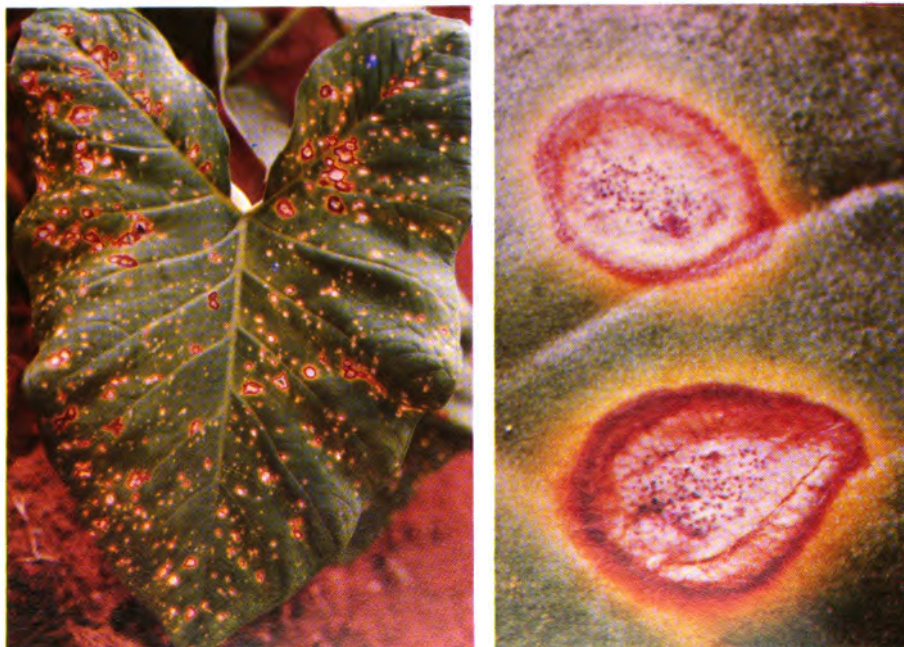
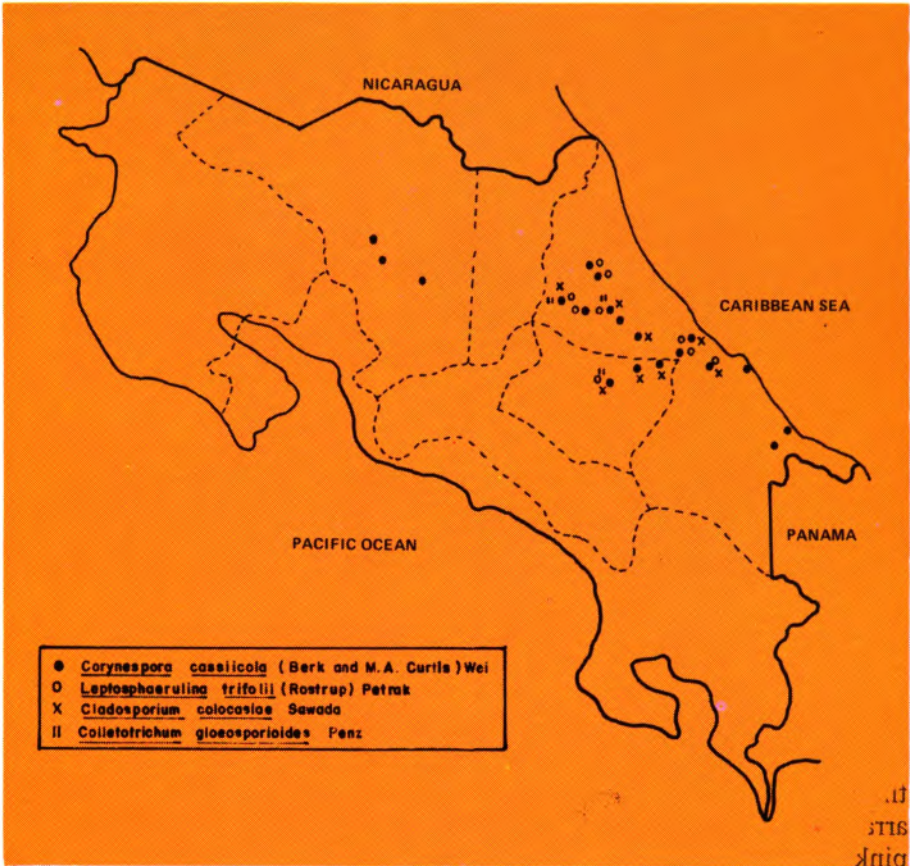


FIGURE 2. a) White cocoyam leaf (*Xanthosoma sagittifolium*) showing *Leptosphaerulina trifolii* Damage. b) *Leptosphaerulina trifolii* lesions with ascocarps.



MAP 2. Distribution of foliar fungi diseases affecting Aroids in Costa Rica.

*trifolii* culture was identified by Dr. A. Sivanesan of Commonwealth Mycological Institute (CMI), where it is stored with the code No. IMI 278645.

This disease is found in white cocoyam, violet cocoyam and taro, although very rarely in the latter. It occurs throughout the Atlantic region, with incidence varying between 20% and 35% in white and violet tiquisque (Map 2).

The disease has been noted in the Solomon Isles (17, 21) as an aroid foliar pathogen.

***Collectotrichum gloeosporioides* Penz:**  
**Concentric leaf spots**

In cocoyam leaves the symptoms appear as roundish or oval reddish brown spots with a diameter varying between 2.5 and 5 cm (Figure 3).



FIGURE 3. a) Concentric leaf spot: *Colletotrichum gloeosporioides* on leaf of white cocoyam. b) Detail of concentric leaf spot.

A few spots are formed per leaf, generally scattered, although two or three may coalesce. They may be found anywhere on the leaf blade. On the surface of the leaf spots, numerous setose acervuli are found arranged in a characteristic concentric pattern (Figure 3b). The orange-pink acervuli measure  $70-85\mu$  in diameter and contain numerous unicellular, cylindrical conidia which are straight with roundish ends. The conidia measure  $10-15 \times 4-5\mu$ . Based on morphological characteristics and culture findings, after the taxonomic work of Von Arx (36), the disease - producing organism was placed within the species *Colletotrichum gloeosporioides*.

Concentric leaf spot has been observed in both white and violet cocoyam (Map 2).

Only one reference to leaf spot in aroids caused by *Colletotrichum* has been found. This cites *Colletotrichum capsici* damage to malanga in Kanpur (4).

### *Corynespora cassicola* (Berk and M.A. Curtis) Wei

First symptoms are small, necrotic, round spots surrounded by a chlorotic halo which grow until they reach a typical oval form between 1.0 cm and 2.5 cm. in diameter (Figure 4a). The spots are reddish brown in color with darker edges. They are usually found singly but in some cases 2 or 3 may coalesce 30 or 40 spots per leaf may occur.

In the centre of the lesion (Figure 4b), fruiting bodies appear as dark, nonbranched conidiophores with scars which allow the conidia to disperse. The conidia are thin, cylindrical and dark green colored with 3 to 10 transverse septae and measure  $45-60\mu \times 8-10\mu$ .

The fungus was identified by Dr. P. M. Kirk of CMI where the culture is maintained under the code number IMI 278646.

*C. cassicola* has only been observed in taro and is widely distributed throughout Costa Rica.

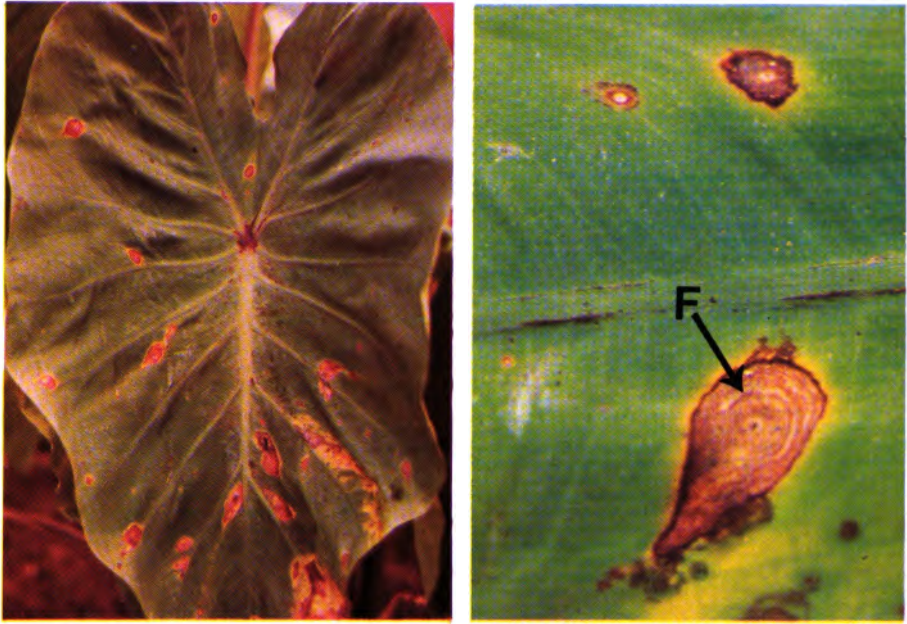


FIGURE 4. a) Leaf of Taro *Colocasia esculenta* showing leaf lesions of *Corynespora cassicola*. b) *Corynespora cassicola* lesions with fruiting bodies.

### *Cladosporium colocasiae* Sawada

In taro leaf lesions are round or roundish brown spots approximately 1.0 - 2.5 cm. diameter (Figure 5). On the underside of the leaf the spots are more diffuse and bigger than those on the upper surface. Damage is seen in both old and young leaves (Figure 6a). If high relative humidity persists for several days, the leaf surface exhibits conidiophores which are elongated, dark, branched at the apex and produce conidia in chains (Figure 6b). The conidia vary in size and shape. Some are rounded and small with a diameter of  $6.3\mu$ , others are cylindrical measuring  $5-7\mu$  by  $10-17.5\mu$  and other are elongated double cells measuring  $5-7\mu$  by  $12.5-20\mu$ .



FIGURE 5. *Cladosporium colocasiae* in taro leaf.

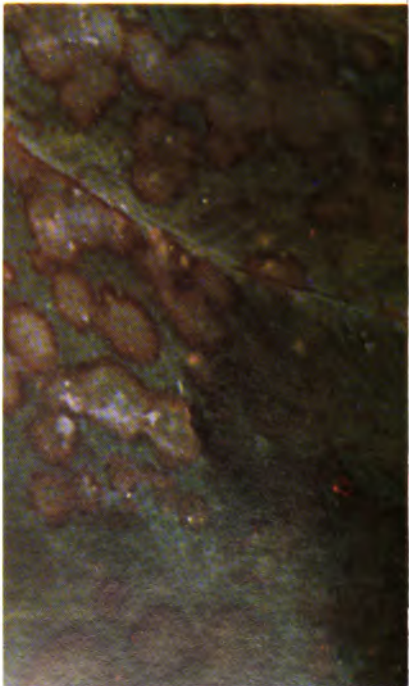


FIGURE 6. a) *Cladosporium colocasiae* leaf spots. b) Detail.

The disease has been called "ghost spot" or "false spot" because the damage is completely superficial in the leaf tissue (19).

*Cladosporium colocasiae* has been reported in Hawaii (28), New Caledonia (2), New Hebrides (22) in Samoa, The Carolinas, The Marianas (27, 34) and India (34). It is a widespread disease of malanga sowings in the Southern Pacific area but the damage it causes is of little economic importance.

In Costa Rica it has only been found in taro and is not widely distributed (Map 2). However, incidence is high (60-90%) in areas where it does occur.

## DISEASES CAUSED BY BACTERIA

### *Xanthomonas campestris* (Panmel) Dowson: Bacterial marginal necrosis

The first symptoms of this disease are marginal necrosis of the leaf which can affect the whole margin or just parts. The necrotic margin is brown and separated from the healthy portion of the leaf by a brilliant yellow chlorotic halo (Figure 7). On the underside of the necrotic area a yellow slime forms (bacterial exudate or zooglea).

The bacteria enter through the hydathodes at the edges of the leaf, where moisture accumulates. There they multiply rapidly and spread to the substomatal cavity. Later they reach the vascular tissue causing tracheobacteriosis and, as a consequence, necrosis of the veins. They also invade the intercellular spaces causing parenchymal tissue necrosis. The necrosis progresses from the leaf margins to the centre by way of protrusions (Figure 8) and eventually the whole leaf dries out.

Occasionally the infection develops by way of the petiole. Initially this appears chlorotic and necrosis progresses from the distal to the proximal end, of the petioles killing it completely (Figure 9).

The causal agent of bacterial marginal necrosis was identified as *Xanthomonas campestris* (Pammel) Dowson, based on morphological, culture and physiological characteristics.

*X. campestris* is widely distributed throughout all areas of cocoyam cultivation (Map 3). It is found in both violet and white cocoyam with an incidence never less than 40 for both species and up to 90 in violet cocoyam in some localities in the Atlantic zone. Incidence percentages in the San Carlos area are lower (20-25%). The disease has been found in taro but the necrosis is restricted to the leaf margin (Figure 10).



**FIGURE 7.** Violet cocoyam leaf with bacterial marginal necrosis.



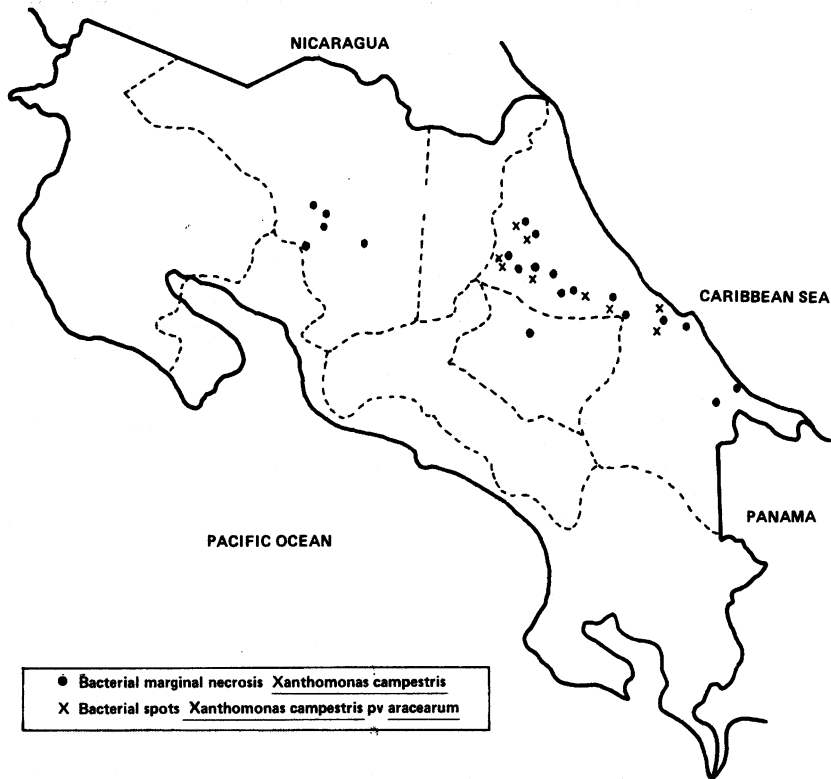
**FIGURE 8.** Advanced necrosis in violet cocoyam.



**FIGURE 9.** Leaf and petiole necrosis in white cocoyam.



**FIGURE 10.** Bacterial marginal necrosis in taro.



MAP 3. Distribution of foliar diseases, caused by bacteria, affecting Aroids in Costa Rica.

Bacterial marginal necrosis has also been observed in wild aroids in Costa Rica.

In the literature consulted, this disease has not been described or reported from other countries which cultivate aroids.

***Xanthomonas campestris* pv. *aracearum* (Berniac) Dye:  
Bacterial spots**

Symptoms occur in young and mature leaves as small, round chlorotic spots between 4 and 10 mm. diameter (Figure 11). These are abundant and usually denser at the leaf margins than at the centre (Figure 12). On the underside of the spots, abundant bright yellow bacterial exudates (zooglea) are found (Figure 13). Sometimes zooglea





FIGURE 11. Bacterial spot in violet cocoyam.



FIGURE 12. Detail of chlorotic leaf spots.



FIGURE 13. Bacterial exudates (zoogonia) of *Xanthomonas campestris* pv. *aracearum* on the lower leaf surface.

can be found on the upper surface of the spot. The zooglea are droplets formed by rapidly multiplying bacteria, and composed of bacterial excretion products and remains of infected plant tissue. They are a means of dispersion and protection for the microorganisms. In severe infections, spots may coalesce, deforming and killing the leaf which eventually falls. The bacterium was identified as *Xanthomonas campestris* pv. *aracearum* (6).

The bacterium spreads with rain, wind, insects and plant to plant contact.

In 1977, Berniac (1) described in the Caribbean region a bacterial disease caused by *Xanthomonas dieffenbachiae* (Mac Culloch et Pirone) Dowson, with similar symptoms to "bacterial spots". Later this organism was designated as (Mac Culloch et Pirone) Dowson, with similar symptoms to "bacterial spots". Later this organism was designated as *Xanthomonas campestris* pv. *aracearum* (Berniac, 1974) Dye, 1978 (1).

In Costa Rica it has only been found in areas of cultivation in the Atlantic region in white and violet cocoyam where in some plantings incidence is up to 95% (Map 3).

The bacterium has also been found in wild aroids exhibiting the same symptoms. So far it has not been found in taro in any of the study areas.

# Diseases in petioles, corms and roots

## BLIGHT

### Root rot-blight complex

The first symptoms are chlorosis of the leaf which spreads towards the petiole. As the disease advances, the above - ground parts of the plant become chlorotic and growth is stunted (Figure 14). In certain cases plant death results, others are permanently stunted and periodically produce one or two new leaves which do not develop normally and also wither. Corms that form are few in number and small but no necrosis is apparent. Root system development is reduced and the majority of the roots die (Figure 15).



FIGURE 14. Blight in violet cocoyam.



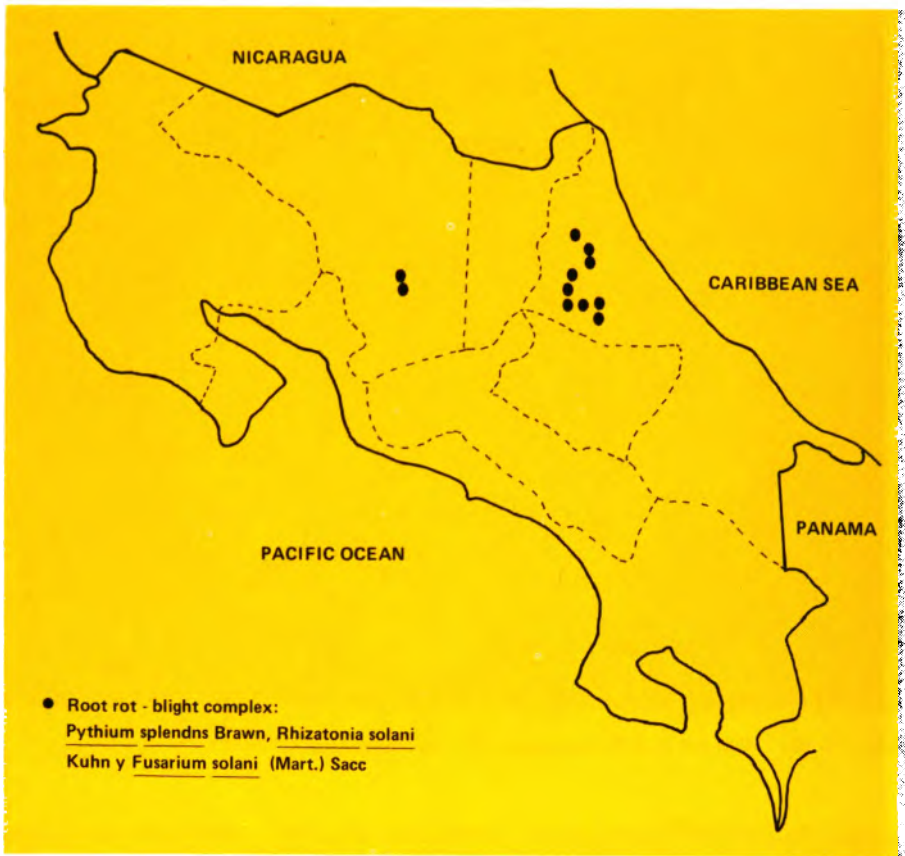
FIGURE 15. Root rot in violet cocoyam. NR: necrotic roots.

It has been observed that, from time to time, the plant produces some roots which allows new leaves to form. The plants can sustain themselves in this condition for the entire vegetative period.

Isolates and pathological tests have shown that this syndrome is caused by the combined action of *Pythium splendens* Brawn, *Rhizoctonia solani* Kühn = *Corticium solani* (Prill y Delacr) Bourd and Galz, and *Fusarium solani* (Mart.) Sacc. *Pythium splendens* Brawn was identified by Dr. D. J. Stamps and the culture is deposited in the IMI of the Commonwealth Mycological Institute (culture number 278644).

In Costa Rica this blight has been observed in white and violet cocoyam in the Atlantic region. A considerable incidence (5% - 40%) was detected in Guapiles, Roxana, Guacimo, Llano Bonito and Cariari (Map 4).

Root rot-blight complex has been mentioned as the most important disease of aroids in Nigeria and Cameroon (16, 20, 26), where it is known by the name "Apolo disease". Research in these countries has shown that the disease occurs mainly in heavy, badly drained soils. These conditions weaken the plant making it susceptible to the micro-organism.



MAP 4. Distribution of Root rot-blight Complex in white cocoyam and violet cocoyam in Costa Rica.

***Corticium rolfsii* (Sacc) Curzi = (*Sclerotium rolfsii*) Sacc.**

The petioles exhibit a dark green or brown, soft, watery rot (Figure 16).

A white mycelium forms at the base of the petioles and below, within which small, uniform-sized sclerotia of diameter 0.8 - 1.2 mm. can be seen. Initially white, they later darken to brown. The mycelium and sclerotia also develop in the surrounding soil (Figure 17). The fungus can remain in the soil for long periods of time as mycelia or sclerotia, even in the absence of susceptible plants. When these are present, the fungus penetrates immediately, disrupting the invade



FIGURE 16. *Corticium rolfsii* rot in petioles of white cocoyam.

tissue. In certain cases the disease reaches the corms causing rot and death leading to wilting of the whole plant (Figure 18). This rot has been found in malanga and both white and violet cocoyam.

It is a widely-distributed disease, occurring in all areas of cultivation but incidence is low (10-15%).

*Corticium rolfsii* has been reported as causing aroid rots in Fiji (5, 27, 35), the Philippines (8, 27, 28, 35), Hawaii (27, 28, 30, 35), India (24), Solomon Isles (11), and Nigeria (15).



FIGURE 17. Mycelia and sclerotia of *Corticium rolfsii*.



FIGURE 18. Wilting caused by *Corticium rolfsii* in cocoyam.

# POST-HARVEST CORM ROT

In packing sheds and in retail outlets taro and cocoyam corm rot is uncommon (7-10% incidence). However, the following have been observed and described:

## *Corticium rolfsii* (Sacc) Curzi

Starting as a soft brown coloured rot, this disease quickly progresses in damp conditions resulting in the rotting of the whole corm in a few days (Figure 19).

The growth of mycelia and sclerotia on the surface of affected corms is frequently observed (Figure 19). This is the most common root rot which appears in corms which have already been harvested.

The disease has been reported in Fiji, the Philippines, Hawaii (27) and in the Solomon Isles (17, 18, 19).

## *Erwinia chrysanthemi* Burkholder, MacFadden and Mimock

Affected corms exhibit a soft, damp rot. The damaged tissue loses its consistency and turns a grey-white colour accompanied by a characteristic fetid odor (Figure 20a). This tissue disintegration is caused by bacterial secretions of pectinolytic and cellulolytic enzymes which dissolve the cell walls causing cell plasmolysis (Figure 20b). The leaking fluid spreads the infection to other corms, especially during prolonged periods of high humidity in the storehouses. Identification of the rot as *E. chrysanthemi* was made by its morphological, culture and physiological characteristics (7).

The bacterium enters the corms via small wounds. In certain cases it will occur following an attack by *Fusarium* spp. or *Pythium* spp. *E. chrysanthemi* has previously been reported in aroid corm in the Solomon Isles (17, 19).

## *Botryodiplodia theobromae* Pat = *Diplodia theobromae*

This spongy rot has been observed in cocoyam and taro where it starts off light brown in colour, later turning grey and darkening until it is almost black (Figure 21). The healthy and infected parts of the corm are distinct. As the rot develops, mycelia and pycnidia can be seen on the outside of the corm.





FIGURE 19. a) *Corticium rolfsii* rot in cocoyam corms external view. b) Cocoyam corms. Internal view of *Corticium rolfsii* rot.

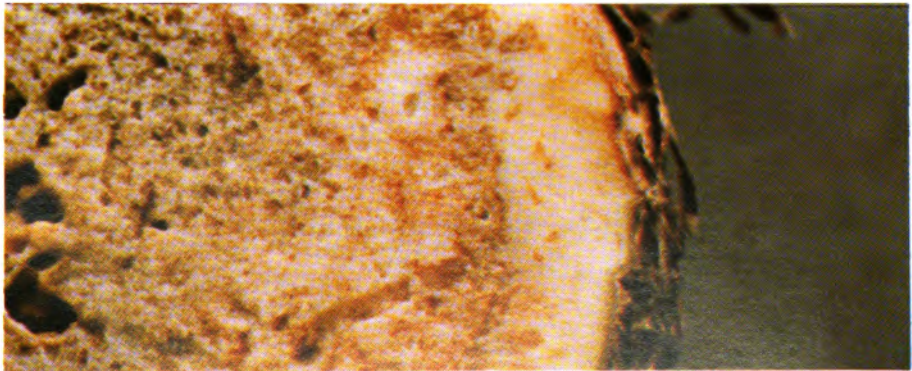


FIGURE 20. a) *Erwinia chrysanthemi* in cocoyam corms. b) Detail of rot.

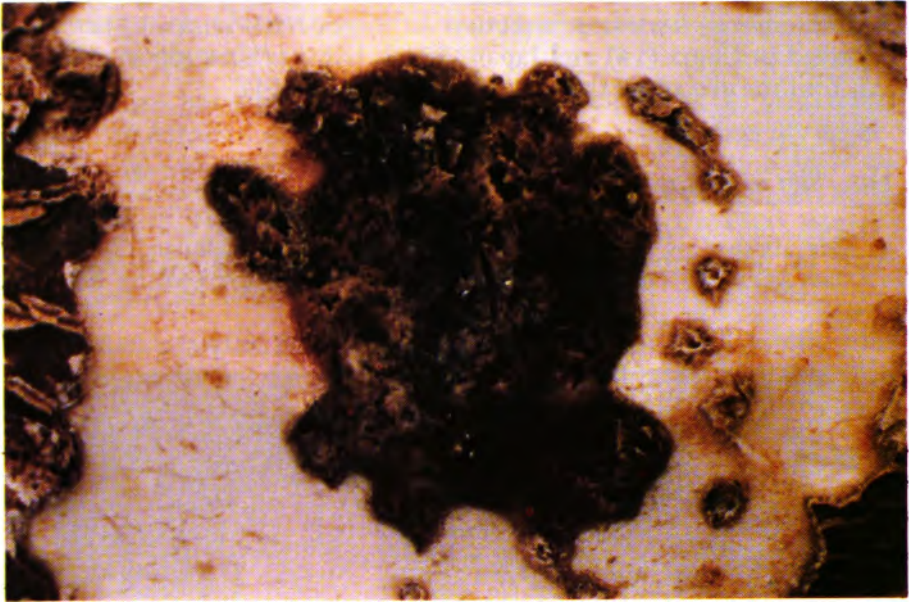


FIGURE 21. *Botrydiplodia theobromae* infection in taro.

The mycelia are dark grey and the pycnidia are stromatic, black, elliptical and clumped, having a mean diameter of  $410\mu$ .

When immature, the pycnidiospores are brown and hyaline. Mature pycnidiospores are bicellular with a mean size of  $14.2 \times 27\mu$ .

This rot occurs very infrequently in Costa Rica but is very common in post-harvest corms in the Solomon Isles (3, 11, 18) and Latin America (25).

### ***Ceratocystis fimbriata* Ell and Halst**

This rot occurs in malanga and tiquisque corms. Initially the affected tissues are light brown in colour and darken later. It is a dry rot and the edge of the infection is poorly defined (Figure 22a).

Sexual and asexual fruiting bodies of *Ceratocystis fimbriata* appear on the affected area as the infection progresses (Figure 22b). These ascocarp are comprised of very dark, almost black, superficial, spherical perithecia with a mean diameter of  $198\mu$ , with a black beak  $808\mu$  long and  $25\mu$  in diameter at the base. The ascospores are hat shaped, characteristic of the species (14, 37), with a mean size of  $5.5\mu \times 4.5\mu$ . The asexual fruiting bodies are made up of two types of endoconidia: one hyaline, cylindrical and truncated with a mean size of  $24\mu \times 5\mu$ , the other olive-brown, thick walled and almost spherical with a mean diameter of  $10.7\mu$ .

*Ceratocystis fimbriata* infection of *Colocasia esculenta* has been reported in China (14) and Japan (23). It has also been reported affecting *Xanthosoma* sp. in the Dominican Republic (14).

***Fusarium oxysporum* Schlecht**

This disease is found in both tiquisque and malanga corms and appears as an off white, spongy rot separated from the healthy tissue by

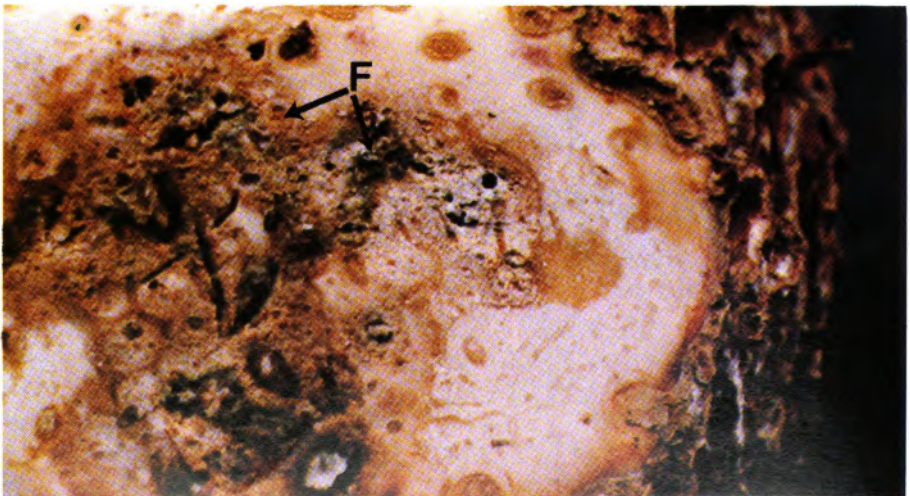


FIGURE 22. a) *Ceratocystis fimbriata* in taro corms. b) Detail of rot. F: grey-green fruiting bodies.

a brown border (Figure 23). If it occurs while the plant is growing it can cause wilting of the aerial portions.

The fungus has a pinky-violet mycelium which colors the medium in which it is cultured. The macroconidia are numerous, generally three-septate, slightly sickle shaped and with rounded ends. The microconidia are cylindrical and generally unicellular. The macroconidia measure between  $25 - 42\mu \times 3.5 - 5.0\mu$  and the microconidia  $6-11\mu \times 2-3.5\mu$ . These morphological characters coincide with those described for *Fusarium oxysporum* Schlecht (10, 20).

*Fusarium oxysporum* rot has been reported from the Solomon Isles where it is known as “u ulu” (11, 12, 21), and is frequently observed in corms arriving at markets in Chicago (3). The rot is favored by high relative humidity and temperatures around  $25^{\circ}\text{C}$  (11).



FIGURE 23. *Fusarium oxysporum* Schlecht in taro corms.

## BIBLIOGRAPHY

1. BERNIAC, M. Une maladie bacteriene de *Xanthosoma sagittifolium* (L.) Schott. Annale Phytopathologie 6(2):197-202. 1974.
2. BUGNICOURT, F. Contribution a l'etude de *Cladosporium colocasiae* Sawada. Revista Mycologica. Paris, 23(2):233-236. 1958.
3. BURTON, C.L. Diseases of Tropical Vegetable on the Chicago Market. Tropical Agriculture 47(4):303-313. 1970.
4. CHAUHAN, S.S. A leaf spot disease of *Colocasia esculenta* Schott. Labdev Journal of Science and Technology B 10(2):92. 1972.
5. DUMBLETON, L.J. A list of plant diseases recorded in South Pacific territories. Association Pacific Commission. 1954. Technics Paper 78. 1954.
6. DYE, D.W., *et al.* International standards for naming pathovars of phytopathogenic bacteria and a list of pathovar names and pathotypes strains. Review of Plant Pathology 59(4):153-168. 1980.
7. ————. A numerical taxonomic study of the genus *Erwinia*. New Zealand Journal of Agricultural Research 24:223-229. 1981.
8. FAJARDO, T.G. y MENDOZA, J.M. Studies on the *Sclerotium rolfsii* Sacc. attacking tomato, peanuts and other plants in the Philippines. The Philippines Journal of Agriculture 6(4):387-429. 1935.
9. FERNANDEZ VALIELA, M.V. Introducción a la Fitopatología. Vol. III. Phycomycetes - Ascomycetes. Buenos Aires, Instituto Nacional de Tecnología Agropecuaria, 1978. 779 p.
10. ————. Introducción a la Fitopatología. Vol. IV. Hongos y Mycoplasmas. Buenos Aires, Instituto Nacional de Tecnología Agropecuaria. 1979. 613 p.
11. GOLLIFER, D.E. y BOOTH, R.H. Storage losses of Taro corms in the British Solomon Islands Protectorate. Annals of Applied Biology 73:349-359. 1973.
12. ————, y BROWN, I.F. Corm rot of *Colocasia esculenta* caused by *Fusarium oxysporum*. Plant Disease Reporter 57 (8):701-703. 1973.
13. HARTER, L.L. Storage rots of economic aroids. Journal Agricultural Research 6:549-574. 1916.
14. HUNT, J. Taxonomy of the Genus *Ceratocystis*. Lloydia 19(1):1-56. 1956.

15. IKEDIUGWU, F.W.O. y OSUDE, P.V. A method for baiting *Corticium rolfsii* and of estimating the sclerotial population in soil. PANS 23(4):395-401. 1977.
16. INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE. Research highlights, Sources of resistance to Cocoyam Root rot Blight. Ibadan, Nigeria. 1981. pp. 48-51.
17. JACKSON, G.V.H. and GOLLIFER, D.E. Disease and Pest Problems of Taro (*Colocasia esculenta* (L.) Schott) in the British Solomon Islands. PANS. 21(1):45-53. 1975.
18. ———, y GOLLIFER, D.E. Storage rots of taro (*Colocasia esculenta*) in the British Solomon Islands. Annals of Applied Biology 80:217-230. 1975.
19. ———. Diseases and Pest of Taro. Sidney, N.S.W. Australia. South Pacific Commission Publications Bureau, 1980. 51 p.
20. JOFFE, A.Z. A modern System of Fusarium Taxonomy. Mycopathologia et Mycologia applicata 53(1-4):201-228. 1974.
21. JOHNSTON, A. A preliminary Plant Disease Survey in the British Solomon Islands Protectorate. Rome, FAO. 1960. 51 p.
22. ———. Host list of plant disease in the New Hebrides. Technics Document 27, Bangkok, FAO, 1963.
23. KAWAKITA, K., KOHIMA, M. The isolation and properties of a factor in taro tuber that agglutinates spores of *Ceratocystis fimbriata*, black rot fungus. Plant and Cell Physiology 24(1):41-49. 1983.
24. KULKARNI, N.B. y AHMED, L. Studies on the basidial formation by *Sclerotium rolfsii* Sacc III. Mycopathologia et Mycologia applicata. 28(1-2):107-108. 1966.
25. LINNEMAN, A.R. Preservation of certain tropical root and tuber crops. Abstracts on Tropical Agriculture 7(1):9-20. 1981.
26. NZIETCHUENG, S. Studies on root-rot disease of cocoyam (*Xanthosoma sagittifolium*) in Camerroom caused by *Pythium myriotylum* Drechl: some aspects of epidemiology and control measures. In 6th. symposium of the International Society for Tropical Root Crops. Lima. International Potato Center. 1983. p. 18.
27. ONWUEME, I.C. The tropical tuber crops; yams, cassava, sweet potato and cocoyams. Chischester, John Wiley, 1979. 229 p.
28. PARRIS, G.K. Diseases of taro in Hawaii and their control. Hawaii Agricultural Experiment Station. Circular No. 18. 1940. pp. 1-29.

29. PFEIFFER, H.J. Preliminary studies on farmer level cultural technics to overcome the macabo (*Xanthosoma* spp.) root-rot disease in Center - South Cameroun. In 6th. Symposium of the International Society for Tropical Root Crops. Lima. International Potato Center. 1983. p. 19.
30. PLUCKNETT, D.L.; DE LA PEÑA, R.S. and OBRERO, F. Taro (*Colocasia esculenta*). Field Crop Abstracts 23(4):413-426. 1970.
31. PRASAD, K. S. y RAO, P.R. Root and corm rot of *Colocasia esculenta*. Indian Phytopathology 23(3):472-473. 1980.
32. SATOUR, M.M.; WEBSTER, R.K.; HEWITT, W.B. Studies on *Diplodia* and *Diplodia*-like Fungi. I. Effects of Carbon Sources on certain taxonomic characteres and on growth in agar culture. Hilgardia 39(22):601-629. 1969.
33. SHARMA, K.D. y UPADHYAY, S.K. Dry rot of *Colocasia esculenta* var. *antiquorum*. Indian Phytopathology 30(3):419-420. 1978.
34. SRIVASTAVA, Y.N. y BHARGAVA, K.S. Fungi causing some new-diseases of two important crop plants in India. Proceedings of the Indian National. Science Academy, B. 43(5):198-200. 1977.
35. TRUJILLO, E.E. Diseases of the genus *Colocasia* in the Pacific Area and their control. In International Symposium on Tropical Root Crops, Trinidad, 1967. Proceedings. Trinidad, University of the West Indies, 1967. pp. 13-18.
36. VON ARX, J.A. Die Arten der Gattung *Colletotrichum* Cda. Phytopathologische Zeitschrift 29:413-468. 1957.
37. WEBSTER, R.K. y BUTLER, E.E. A morphological and biological concept of the species *Ceratocystis fimbriata*. Canadian Journal of Botany 45 (9):1457-1468. 1967.
38. WILLIAMSON, D. y TANDON, R.N. Some pathological studies on *Botryodiplodia theobromae* Pat causing banana rot. Mycopathologia et Mycologia Applicata 29:245-253. 1965.
39. YOUNG, J.M., *et al.* A proposed nomenclature and classification for plant pathogenic bacteria. New Zealand Journal of Agricultural Research. 21:153-177. 1978.





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