la diferencia es significativa ($P < 0.001$) con respecto al testigo.

3. Tratamientos de 24 horas de inmersión en agua a temperatura ambiente produjeron un índice de germinación del 11%. Esta cifra no es significativamente diferente del testigo (9%).

4. Las semillas de *E. cyclocarpum* no germinadas después de tratamientos con H_2SO_4, agua caliente, agua a temperatura ambiente y sin tratamiento, pueden permanecer enterradas durante dos meses sin perder su viabilidad. Después de este tiempo, un tratamiento con agua hirviendo puede activar la germinación y producir un índice y un patrón germinativo similar al del primer tratamiento con agua hirviendo.

Resumen

Inmersión de semillas de *E. cyclocarpum* en ácido sulfúrico concentrado y agua caliente elevan el índice de germinación a 87.4 y 83.2% respectivamente, mientras que semillas sin tratamiento alguno mostraron un índice de apenas 9.0%. Los tratamientos con ácido y agua caliente concentran la mayor parte de la germinación total en los primeros 12 días después de aplicación. Estos mismos tratamientos aplicados en semillas que han estado enterradas por 2 meses en suelo húmedo, produjeron un patrón germinativo muy similar.

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Ecological upset and recuperation of natural control of insect pests in some Costa Rican banana plantations[1]

Resumen. Los ecosistemas en el suroeste de Costa Rica cambiaron drásticamente después de que se desarrollaron las plantaciones bananeras. Excepto por el daño causado por 2 insectos, el daño causado a las plantaciones bananeras por especies potenciales de plagas nativas fue mínimo antes de que se aplicaran insecticidas. Después que se iniciaron los tratamientos con insecticidas en los años 1950's aparecieron nuevas plagas en cantidades devastadoras. Se estudiaron la parte bionómica, los controles naturales y químicos de las plagas. Parásitos y predadores de las especies de las plagas presentes fueron fácilmente colectados en áreas no tratadas, pero los agentes de control natural fueron suprimidos en las plantaciones de banano rociadas con plaguicidas. En 1973 todas las rociaduras con insecticidas fueron canceladas. Rápidamente las plagas disminuyeron. En un período de 2 años, un ecosistema balanceado en las áreas bananeras fue restabilizado otra vez y muchas plagas prácticamente desaparecieron. Luego de 10 años se ha obtenido un eficaz control de estas plagas por medios naturales, sirviendo ahora como modelo demostrativo de la confiabilidad de tal estrategia.

Banana plantations were developed by the United Fruit Company during the 1940-50's in alluvial plains north and east of Golfo Dulce in southwest Costa Rica. Prior to 1938, this area was a virgin wilderness of evergreen lowland forest with almost no human habitation (1). According to L. R. Holdridge's classification of life zones, the zone was a tropical wet forest

1 Project developed when the author was Experimental Director for Compañía Bananera de Costa Rica, Golfito, Costa Rica.

(11). Gros Michel bananas were planted in the Rio Terraba-Rio Sierpe Valley near Palmar, the Rio Esquinas-Rio Piedras Blancas area, the Coto Valley, and the Colorado-Laurel District along the Panama border near Rio La Vaca and Rio Colorado. Heavy rainfall occurs in these zones between April and December but a dry season persists during January through March. Annual rainfall averages 3 593 mm in Palmar, 5 354 mm in Piedras Blancas-Esquinas, 3 712 mm in Coto and 3 237 mm in Laurel along the Panama border. When the last virgin soils were planted with the Cocos variety of banana in Coto in 1962, approximately 30 000 hectares of forest had been felled during the previous 2 decades for banana production. Within 5 years after planting, many of these cultivations were abandoned because of Panama disease, *Fusarium oxysporum* Schlecht. f. sp. *cubense* (E. F. Smith) Snyder and Hansen.

The banana plantations represented a drastic ecological change from a climax forest ecosystem to a monoculture crop. Once banana plantations became established, a new ecosystem evolved. Within this new ecosystem, native potential insect pests were kept in balance by natural control agents. Thus, insect damage to bananas was minimized up to the mid-1950's.

Before the mid-1950's, only 2 insect species were considered economically important. The banana corm weevil, *Cosmopolites sordidus* Germar, was introduced in banana corms shipped in for plant propagation. Larvae cause damage by boring into the corm. The species is present throughout banana-growing areas of the world (15, 19). A native thrips, *Chaetanophothrips orchidii* (Moulton), a parthenogenic species, causes a "red rust" blemish on the peel of the fruit by feeding between adjacent banana fingers (15, 16, 20). Attempts to control these 2 pests in the 1950's resulted in drastic ecological upsets which set off a chain reaction of unfavorable events that lasted into the early 1970's.

Cause and effect

The mass application of dieldrin granules in 1954 by airplane over 12 000 hectares of bananas for the control of the red rust thrips resulted in rapid and complete control. Dieldrin spray and granules were also applied to the base of banana plants for controlling the banana corm weevil. Within a few months after dieldrin granules were applied by air, an epidemic of the banana stalk borer, *Castniomera humbolti* (Boisduval), suddenly appeared and resulted in heavy losses. This lepidopterous larva bores through the pseudostem and weakens the trunk (3, 12). Similar epidemics of *Castniomera* on the Atlantic coast of Costa Rica were reported by Lara (12, 13, 14). Another lepidopterous pest, *Platynota rostrana* (Walker), suddenly appeared and caused great losses of fruit by feeding between banana fingers (2, 17).

Before 1958, Sigatoka leaf spot, *Mycosphaerella musicola* Leach, was controlled with Bordeaux spray, a copper sulphate-lime mixture, which was sprayed onto the leaves from the ground at high volumes every 7 days (23). Several studies suggested that Bordeaux spray partially inhibited the development of several defoliators (17, 24, unpublished data). In 1958, high volume Bordeaux spray was replaced by low volume fungicidal orchard oil sprays applied by air (23). Dieldrin was added to aerial oil spray for the control of red rust thrips. Previously, dieldrin and other chlorinated hydrocarbon pesticides were sprayed onto the fruit through a Sigatoka hose spray system (24).

During 1954-58, severe ecological damage to the banana ecosystem resulted in unprecedented outbreaks of banana insect pests particularly in 1958. Most entomologists blamed this upset on the mass use of insecticides. Non-entomologists tended to blame the switch from Bordeaux to orchard oil sprays, but this concept was not supported by Harrison's studies on pests and parasites in oil-sprayed areas (6). Similar ecological disturbances had developed in banana plantations in Honduras and Panama simultaneously (unpublished data). By 1959, 4 more research entomologists were employed to study pest outbreaks in Costa Rica and elsewhere.

Entomologists focuses on the bionomics, natural and chemical control of current pests. Table 1 lists the major lepidopterous banana defoliators. Numerous natural control agents were collected from many pests (5, 6, 7, 8, 9, 10, 21). Natural control agents were collected from pests in banana farms, but beneficial species were constantly suppressed by pesticide applications. However, parasites and predators were readily collected from marginal zones between banana farms and the forest. Roth made a study on 23 species of ants in the Palmar plantations (18). Ants were credited with helping to control *C. humbolti* (13, 17). Also, several *Pleidole* ant species are hosts of the parasitic eucharid wasp, *Orasema costaricensis* Wheeler & Wheeler, which causes blemishes on fruit by ovipositing into the peel (15).

Resistance to dieldrin by ceramidia caterpillars, *Antichloris viridis* Druce, in the Esquinas District was reported by R. V. Roig (unpublished data). R. D. Caid reported dieldrin resistance in banana corm weevils in Palmar and Coto in 1963 (unpublished data).

Table 1. Major lepidopterous banana defoliators, Golfito Zone, Costa Rica, 1959.

Common Name	Family	Genus	Species	Author	References
Ceramidia	Syntomidae Revised to:	*Ceramidia*	*butleri*	Moschler	5, 6, 8, 9, 15, 17, 24
Ceramidia	Ctenuchidae	*Antichloris*	*viridis*	Druce	4
West Indian bagworm	Psychidae	*Oiketicus*	*kirbyi*	Guilding	21
Saddleback	Limacodidae	*Sibine*	*apicalis*	Dyar	7, 22
Bluenose	Limacodidae	*Sibine*	*nr. horrida*	Dyar	22
Owleye	Nymphalidae	*Caligo*	*memnon*	Felder	7
Owleye	Nymphalidae	*Opsiphanes*	*tamarindi*	Felder	7

In 1959, dieldrin was replaced by carbaryl (Sevin), which controlled all of the current defoliators except the West Indian bagworm, *Oiketicus kirbyi* Guilding, which was controlled by toxaphene and *Bacillus thuringiensis* Berliner. During the 1960's, high infestations of bagworms and ceramidia were common. Ceramidia were constantly treated with aerial applications of Sevin. Some areas in Coto received 12 treatments in 1962. During that year, 87 000 kg of 85% Sevin were sprayed. Ceramidia were treated when infestations averaged about 5 larvae per leaf but counts frequently reached 50 larvae per leaf. In 1963, US$ 220 000 were spent on caterpillar control (unpublished data).

The ecosystem once again changed when the remaining Gros Michel and Cocos varieties were chopped down because of their susceptibility to Panama disease. From 1964-69, abandoned farms were replanted with the Panama disease-resistant variety, Valery

Results and conclusions

In the mid-1960's, Ostmark demonstrated that the banana plant could tolerate much more insect defoliation without causing premature ripening and loss of fruit weight (unpublished data, 15). Despite this important finding, insecticide spraying continued out of a general fear of any larval infestations. Gradually, more caterpillars per leaf were tolerated and fewer treatments were made by the early 1970's. In 1973, a decision to stop all insecticide sprays was enforced in the entire Golfito banana division. Soon after the ban, insect pests rapidly decreased. Within 2 years after insecticides were halted, a balanced banana ecosystem became restabilized again and most of the previous pest species nearly disappeared. Only occassional minor infestations of *Sibine* or *Oiketicus* appeared but such populations were tolerated without the thought of treatments. Natural control agents reduced the pests below economic thresholds within 1-3 generations with little or no fruit loss. *Antichloris*, *Caligo*, and *Platynota* were rarely seen. *C. sordidus* decreased to an average of less than 1 weevil per trap. Red rust thrips damage was prevented by the use of plastic bags placed on the fruit. The banana aphid, *Pentalonia nigronervosa* Coquerel, previously caused severe sooty mold in the fruit and insecticide-treated plastic bags had to be used to control the pest in the 1960's Since sprays ceased, the aphid and sooty mold problem decreased to low levels and treated fruit bags were no longer needed for aphid control.

Banana farms in the Golfito zone have not been sprayed with insecticides since 1973. After 10 years, successful control of insect pests by natural means now serves as a model demonstrating the feasibility and reliability of such a strategy.

Summary

Ecosystems in southwestern Costa Rica changed drastically after banana plantations were developed. Except for damage by red rust thrips and corm weevils, damage to bananas by native potential pests species was minimal before insecticides were applied. After insecticide treatments were initiated in the 1950's, devastating outbreaks of new pests appeared. The bionomics, natural and chemical control of pests were studied. Parasites and predators of pest species were common in non-treated environments but natural control agents were suppressed in banana plantations sprayed with pesticides. In 1973, all insecticide sprays were stopped. Soon after, insect pests decreased. Within 2 years, a balanced banana ecosystem became restabilized again and many former insect pests nearly disappeared. After 10

years, successful control of insect pests by natural means now serves as a model demonstrating the reliability of such a strategy.

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Pudrición del fruto del banano causada por *Sclerotinia sclerotiorum* (Lib.) de Bary (*Whetzelinia sclerotiorum*) en Costa Rica

Summary. A disease of the banana fruit caused by *Sclerotinia sclerotiorum* (Lib) de Bary (*Whetzelinia sclerotiorum*) was observed in the Experimental Station of the Tropical Agricultural Training & Research Center, CATIE, at Turrialba, Costa Rica. The symptoms included brown colored rot which spread from the distal to the proximal end of the fruit, subsequently covering it entirely. There were no signs of sexual structures on the plant material or on the fungus isolates.

En el área experimental del Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) en Turrialba, Costa Rica, se observó en 1982 una pudrición en los frutos de algunas plantas de bananos del cultivar Cavendish. La pudrición se manifestaba al comienzo mediante un cambio de color en frutos ya desarrollados, que se tornaba de color marrón claro con aspecto acuoso. Esta condición progresaba desde el extremo distal al proximal, llegando a cubrir la totalidad de los frutos (Figura 1). El color del área afectada se modifica paulatinamente hasta alcanzar un tono marrón oscuro casi negro. En la parte interna del fruto, se presentaba también pudrición suave de tejido, de color marrón rojizo. El área afectada se cubrió de micelio blanco en el que se diferenciaba a simple vista; esclerocios del hongo. No se observaron síntomas en el tallo ni en las hojas.

El agente causal de esta enfermedad, *Sclerotinia sclerotiorum* (Lib.) de Bary (*Whetzelinia sclerotiorum*), ha sido señalado con poca frecuencia atacando frutos de banano en países tropicales. Debido a que aún no se ha descrito en Costa Rica, se consideró de interés indicar su presencia.

Esta pudrición de frutos fue señalada en Palestina en el cultivar Dwarf Cavendish, por Reichert y Hellinger (1930), como la pudrición más importante de frutos de banano en la región de Jaffa. En 1970, Loville (3) en su estudio de las enfermedades fungosas del banano en diversos países, señala *S. sclerotiorum* entre las pudriciones más importantes de los frutos. Stover (5) describe la enfermedad como de ocurrencia poco frecuente. En 1974 fue señalada en Bermuda por Waterson (7).

Materiales y métodos

El material que se utilizó para los aislamientos, provino de frutos con síntomas del cultivar Cavendish, de las plantaciones ubicadas en el área experimental del Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), de Turrialba, Costa Rica. Esta localidad está a 600 metros sobre el nivel del mar; ecológicamente se describe como bosque tropical húmedo con transición a muy húmedo; con un promedio de 2 600 mm de precipitación anual, una temperatura promedio de 22.3°C y una radiación de 154 kcal cm^{-2}.

El material enfermo colectado se desinfectó superficialmente con hipoclorito de sodio al 2%, y se cultivó en agar papa glucosado a pH 6, 5, incubándose a 25°C. Las colonias fungosas obtenidas se usaron para el estudio morfológico del hongo y para las pruebas de patogenicidad.

En estas pruebas, se utilizó como inóculo el micelio y los esclerocios que crecían profusamente en Erlermeyers con agar papa glucosado, los frutos para inocular se lavaron y desinfectaron con hipoclorito de sodio al 2%.

En las pruebas de patogenicidad se utilizaron 22 frutos en total. Seis de estos frutos se hirieron con

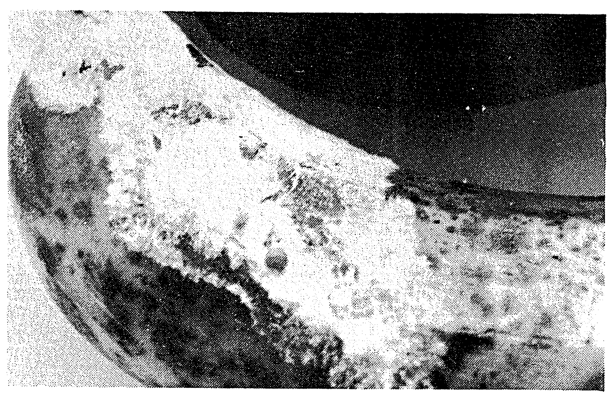

Fig. 1. Fruto de banano mostrando síntomas de pudrición causada por *Sclerotinia sclerotiorum* en Turrialba, Costa Rica. Se observa micelio y esclerocios.