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ALGUNAS CARACTERISTICAS DE LA PRECIPITACION EN PALMIRA, COLOMBIA[1] /

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Summary

The rainfall data for Palmira City for the period 1930-1980 were statistically and mathematically analyzed in order to study some of its characteristics such as secular trend and periodicity.

There was a significant upward trend in the number of days of rain per year during the period. The distribution of annual rainfall showed a 17-year cycle, but the sample size is too small to establish true periodicity.

Introducción

La precipitación es uno de los elementos meteorológicos que mayor incidencia tiene sobre la producción agropecuaria y en muchas otras actividades del hombre. Su reconocida importancia, obliga a que se estudie más en detalle el comportamiento de este elemento climático. No basta y tampoco tiene gran importancia la sola determinación de la lluvia promedia, puesto que este valor no considera fluctuaciones (épocas lluviosas o secas), las que conllevan a situaciones difíciles para la producción agropecuaria.

Por lo anterior, en este artículo se pretende ofrecer la información necesaria para el planeamiento agrícola y complementar algunas publicaciones realizadas sobre el mismo tema por Gómez (8) y Gómez e Ibarra (9).

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Gómez e Ibarra (9), analizaron algunos aspectos de la precipitación en el Centro Nacional de Investigaciones Agropecuarias Palmira entre 1930 y 1964. Dichos autores dividieron el año en dos períodos en los cuales los cultivos necesitan agua.

Entre sus conclusiones podemos citar las siguientes:

1. La cantidad de lluvia durante los dos períodos es igual (marzo-junio y octubre-enero).

2. Mejor distribución de las lluvias en el segundo semestre.

3. Las épocas más aptas para iniciar las siembras en Palmira y zonas aledañas para un agricultor que no posee riego, son probablemente los cinco últimos días de marzo y setiembre, para el primero y segundo semestre respectivamente.

4. La cantidad y distribución de las lluvias hace necesario el riego suplementario en los cultivos.

En otra publicación, Gómez (8) calculó probabilidades (frecuencia relativa) por día en Palmira. Por lo menos 55 periodicidades de más de un año de longitud han sido descritas, variando desde 1.03 a 36 años, siendo las más universales las de 2.5, 3.5, 5 a 6, 11 a

12, 19 a 24 y 30 a 35 años en registros de presión, temperatura, precipitación y condiciones extremas de tiempo en muchos puntos de la superficie terrestre (12).

Burroughs (3) señala que los ciclos no deben mezclarse con aquellos impuestos externamente, porque una periodicidad que coincida con alguna fuerza exterior identificada (por ejemplo manchas solares), es una trampa climatológica que se debe evitar.

Este comentario no descarta por supuesto la existencia de ciclos reales relacionados con la variabilidad solar, aunque ellos meramente proporcionan palabras de advertencia (3).

Materiales y métodos

Se utilizaron los datos que sobre precipitación diaria y mensual posee ininterrumpidamente (1930-1980) la Estación Meteorológica del Centro Experimental Palmira, en Palmira, Departamento del Valle del Cauca (latitud: 3°31' N; longitud: 76° 10'O; altitud: 1 000 m.s.n.m.). La localidad es representativa de un ambiente tropical, isotermal, con dos períodos de máxima precipitación, incluyéndose en el tipo climático A_w"i de Köppen.

Los totales anuales de lluvia se establecieron de abril a marzo, ya que este período constituye realmente el año pluviométrico.

La precipitación semanal se fijó por grupos de siete días, iniciando el primero de marzo y terminando con una semana "falsa" que es la número 53 que corresponde a febrero 28 ó 28 y 29 en el caso de año bisiesto (4).

Las normales semanales, mensuales y anual se calcularon entre 1931 y 1980, de acuerdo a la recomendación dada por la Organización Meteorológica Mundial (WMO) en 1956.

Resultados y discusión

Series de tiempo

Por serie de tiempo se entiende una serie de observaciones del mismo fenómeno organizado cronológicamente, estando los datos igualmente espaciados en tiempo (12). En estas series se analizan: 1) los movimientos seculares o de larga duración; 2) la periodicidad y 3) otras características.

Movimientos seculares

Estos movimientos indican la tendencia a largo plazo de una serie de observaciones descartando las variaciones cíclicas. Para calcular las líneas de tendencia en el presente estudio se utilizó el método de mínimos cuadrados, las cuales aparecen representadas en la Figura 1.

La ecuación hallada para la tendencia secular de precipitación anual fue

$$Y'_c = 1017.6 + 1.74\,X \qquad (I)$$

mientras que para la tendencia secular de días de lluvia fue

$$Y''_c = 133.0 + 1.50\,X \qquad (II)$$

El coeficiente de regresión de la ecuación I no fue significativo en el nivel de probabilidad de 5%, cuando se trató de probar la hipótesis $H_0: b = 0$, es decir la línea de regresión tiene una pendiente que no es significativamente diferente de cero, pero el coeficiente de la ecuación II si fue significativo al nivel de 1%.

Periodicidad

Un fenómeno es periódico, cuando los valores de la variable dependiente (en este caso precipitación) son repetidos en intérvalos iguales de la variable independiente, que usualmente es tiempo (5). Estos ciclos son una característica común de las series meteorológicas (3).

Uno de los métodos que se utiliza para describir la periodicidad de un fenómeno es el Análisis Armónico, que hace uso de la Serie de Fourier. Esta técnica revela ciclos, proporcionales a la longitud de la sucesión de datos (12).

El análisis hecho a la serie presenta oscilaciones con ciclos más o menos definidos de aproximadamente 17 años, además de otro de menor amplitud con períodos aproximados de 8.5 años, como se aprecia en la Figura 2.

Como el Análisis Armónico no detecta algunas pequeñas variaciones periódicas las cuales permanecen ocultas, se recurrió a los modelos de Densidad Espectral y Periodograma, cuyas representaciones aparecen en las Figuras 3 y 4 respectivamente. Los picos indican que los ciclos reales más prominentes de la precipitación en Palmira, son de 16.67, 4.54 y 2.17 años.

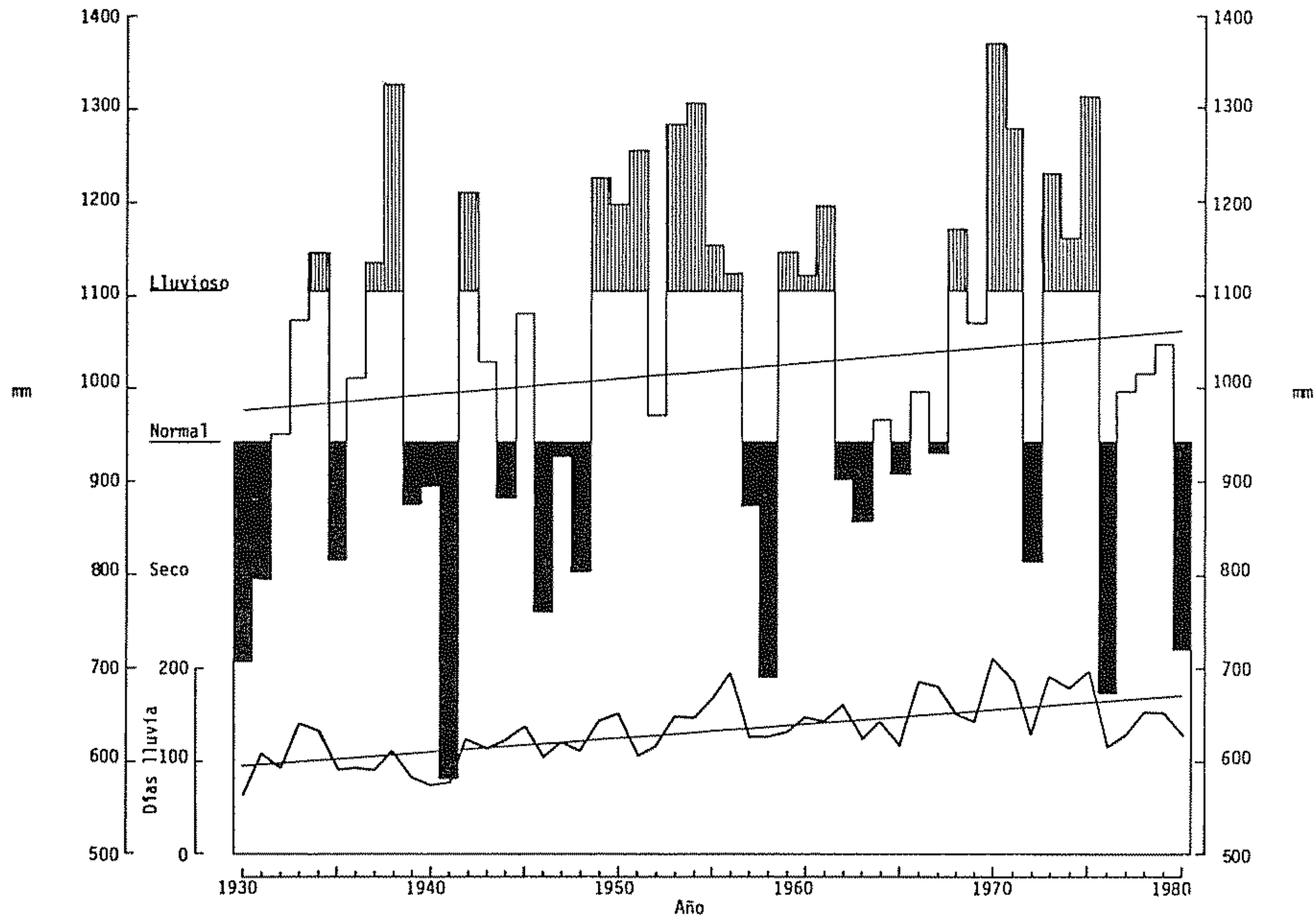

Fig. 1. Totales anuales de precipitación y frecuencia de días lluvia y sus respectivas líneas de tendencia secular en Palmira (1930–1980).

Como los métodos empleados anteriormente se basan en la Transformación de Fourier y por ende dependen de la longitud de la serie, se procedió a utilizar la Función de Autocorrelación (Figura 5), la cual detecta períodos que no son proporcionales tanto de éstos como de la longitud total de la serie original (12). Los ciclos encontrados por medio del modelo anterior, coinciden con aquellos dados por el Periodograma y Densidad Espectral.

La periodicidad cuasi-bienal (ciclos entre 2 y 3 años) es la única oscilación cuya significancia ha sido claramente demostrada. Sin embargo, los otros ciclos encontrados deben considerarse representativos pues los métodos utilizados (Densidad Espectral, Periodograma y Autocorrelación) así lo sugieren (3).

Sumándose trigonométricamente estos ciclos, se obtiene una curva que suaviza la tendencia de la serie original, permitiendo el pronóstico anticipado de épocas con abundante o escasa precipitación (Figura 6).

Este pronóstico no tiene por objeto precisar cantidad o año de ocurrencia de abundante o escasa precipitación, sino establecer cual puede ser el comportamiento futuro tomando como base la tendencia general, debido a que los ritmos usualmente son irregulares en fase y/o amplitud y no son constantes de una región a otra. A pesar del riesgo que conlleva la extrapolación (3), los resultados obtenidos sugieren un período de abundantes lluvias entre los años 1985 y 1988.

Para evaluar mejor la curva, ésta se cotejó con los datos originales (Figura 6) y los promedios móviles de tres, cinco y siete años (Figura 7). En la curva de datos originales, las oscilaciones de ciertos períodos dificultan un poco la identificación de los ciclos a consecuencia de una concentración de valores bajos

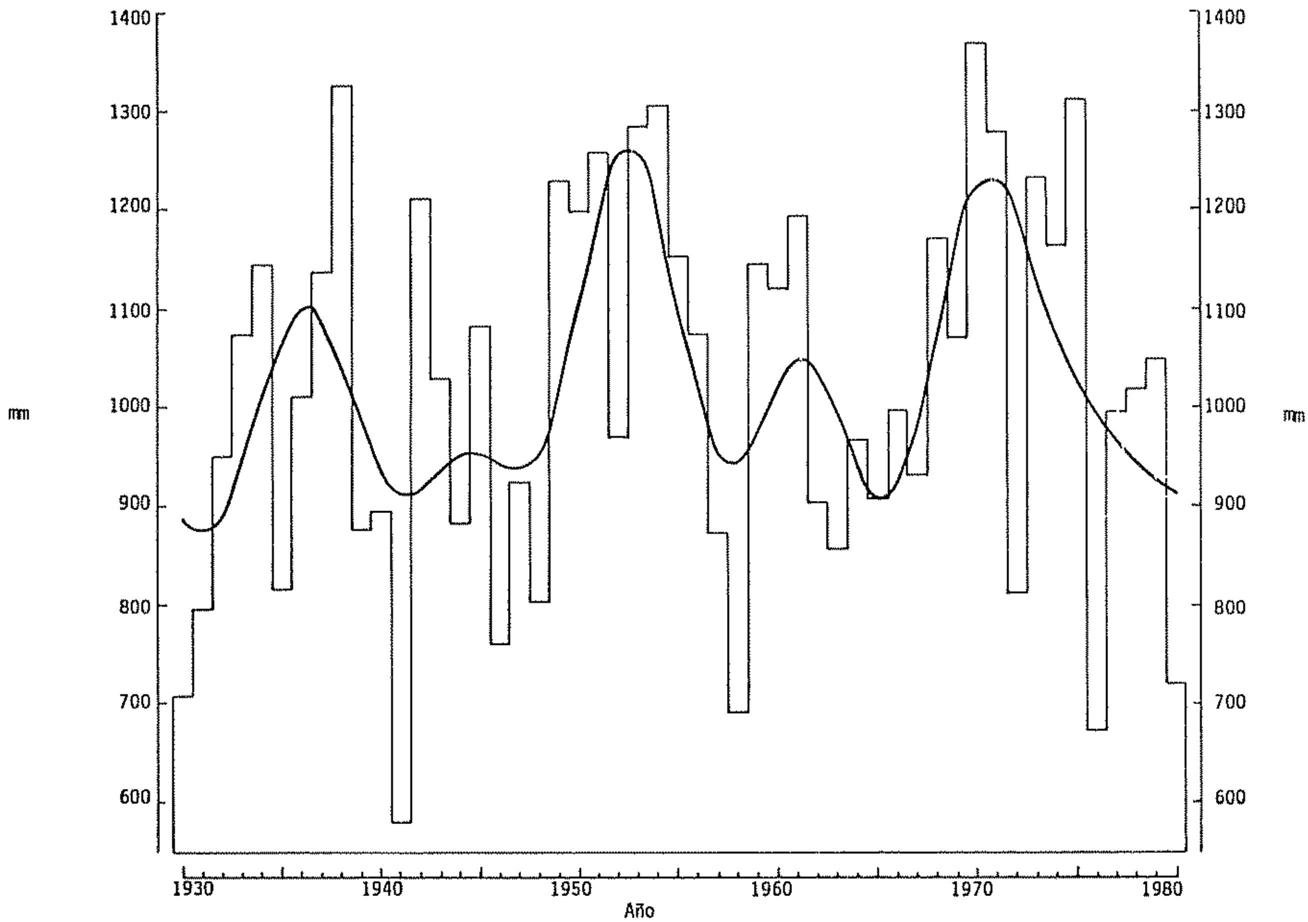

Fig. 2. Curva armónica y totales anuales de precipitación en Palmira (1930–1980).

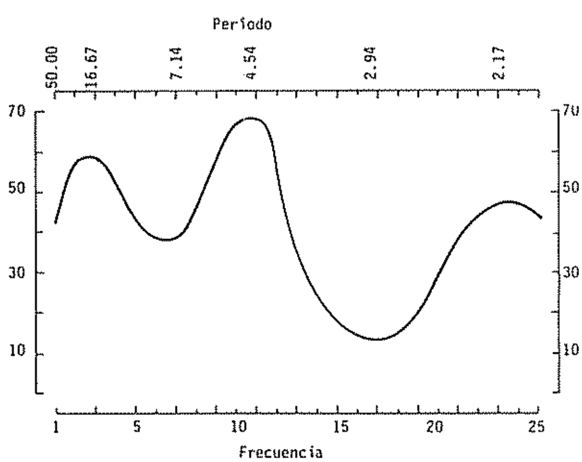

Fig. 3. Densidad espectral de la precipitación en Palmira (1930–1980).

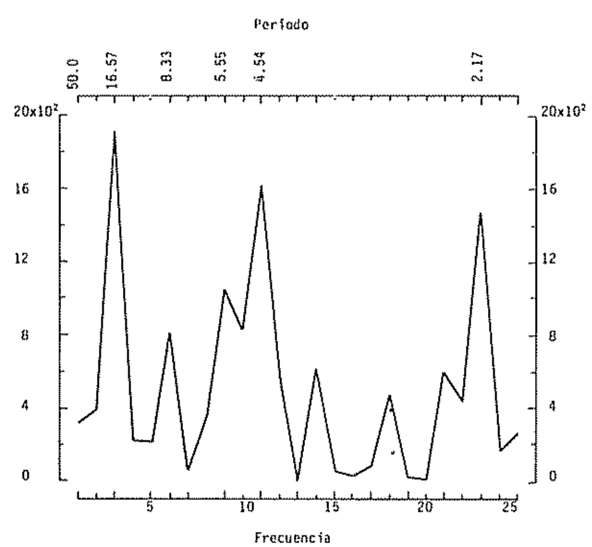

Fig. 4. Periodograma de la precipitación anual en Palmira (1931–1980).

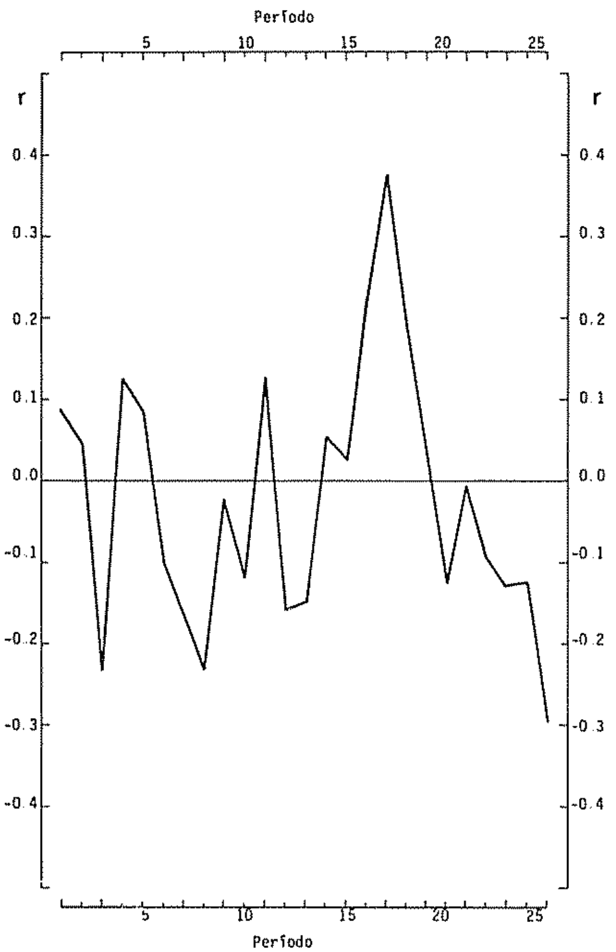

Fig. 5. Autocorrelograma de la precipitación en Palmira (1930–1980).

que corresponden al máximo de la curva de tendencia o viceversa.

Con el promedio móvil de cinco años se consigue una buena correspondencia (Figura 7b), ya que con el de tres se obtiene poca suavización y no se alcanza a eliminar algunas irregularidades que enmascaran el modelo (Figura 7a). Con el promedio de siete años se excede en la suavización, ocasionando la destrucción de algunas características (Figura 7c). El promedio móvil tiene como propósito suavizar las fluctuaciones de más alta frecuencia, de modo que las más bajas pueden ser descubiertas más fácilmente (10).

Otras características

La repartición anual de las lluvias en Palmira no es uniforme y su variación en el transcurso de los años es amplia, observándose períodos con precipitación abundante o reducida lo que constituye los excesos y las sequías que son de variada duración

La precipitación normal es de 1024 mm/año, con desviaciones máximas respecto a esta media en ambos sentidos de (+) 345 y (−) 445 mm/año, notándose mayor frecuencia en las lluvias que están comprendidas entre 870 y 1170 mm/año.

En la Figura 8, se observa que la precipitación durante el año sigue un ritmo característico, constituido por dos épocas de precipitación relativamente abundante, que se extienden normalmente desde la semana 5 a la 14 y de la 31 a la 38 y dos épocas relativamente

Cuadro 1. Precipitaciones extremas anuales, mensuales y diarias en Palmira (1930 – 1980).

	Máxima mensual		Mínima mensual		Máxima diaria	
	Cantidad mm/mes	Fecha	Cantidad mm/mes	Fecha	Cantidad mm/día	Fecha
Enero	195.6	1943	4.4	1948	75.3	29/1971
Febrero	204.5	1950	5.0	1961	71.0	10/1950
Marzo	253.9	1971	17.8	1959	87.6	9/1981
Abril	359.6	1965	26.8	1940	96.4	24/1965
Mayo	297.5	1959	11.1	1961	108.3	29/1959
Junio	214.6	1964	6.0	1941	74.0	30/1964
Julio	93.4	1954	0.0	1940	51.5	7/1975
Agosto	113.2	1972	1.0	1940	45.0	31/1973
Setiembre	154.4	1968	1.2	1976	69.7	1/1968
Octubre	324.2	1961	43.1	1958	78.7	30/1961
Noviembre	328.6	1951	32.5	1930	65.0	17/1951
Diciembre	226.6	1937	16.9	1969	61.7	23/1955

Máxima anual . . . . 1 368.6 mm/año
Mínima anual . . . . 579.4 mm/año

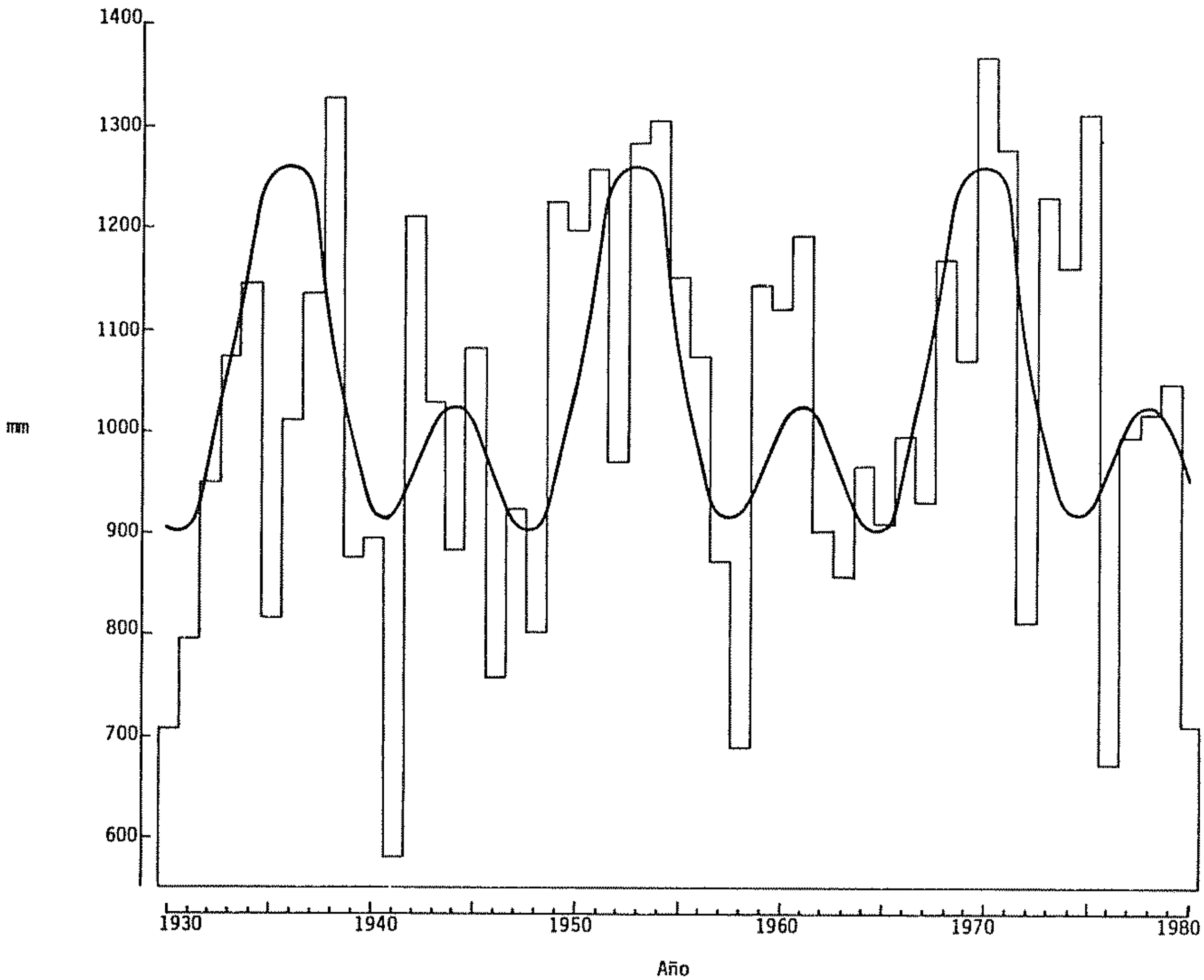

Fig. 6. Tendencia general y totales anuales de precipitación en Palmira (1930–1980).

secas que van desde la semana 17 a la 30 y de la 43 a la 53.

Lo anterior muestra, que los dos períodos lluviosos se alternan con los dos secos. Esta distribución obedece a la proximidad de Palmira con el Ecuador y por estar ubicada en un valle a baja altitud entre dos vertientes a pesar de encontrarse en el área de influencia de la zona de Convergencia Intertropical (ITCZ) (6).

En la Figura 9 se observa en forma general que en esta región predominan las lluvias nocturnas (19 – 07), las cuales son ocasionadas por el sistema de circulación local del viento Valle-Montaña (13). Aproximadamente el 70% de estas precipitaciones ocurren durante la noche.

La intensidad promedia de las lluvias en Palmira es de 3 mm/hora, pero la máxima cantidad recibida en 10 minutos es de 15.6 mm.

La prueba de Shapiro y Wilks (11), indica que la precipitación se distribuye normalmente pues reportó no significación al nivel del 50%. Esto permitió establecer, como se aprecia en las Figuras 1, 3 y 4, las cantidades límites para calificar cuando un año, un semestre o una semana es lluvioso, normal o seco.

El ordenamiento de los meses partiendo del más seco al más lluvioso es el siguiente: julio (a), agosto (a), setiembre (a), febrero (b), enero (b), junio (b), diciembre (b y c), marzo (c y d), noviembre (d), mayo (e), abril (e y f) y octubre (f). Este orden discrepa del establecido por Gómez e Ibarra (9),

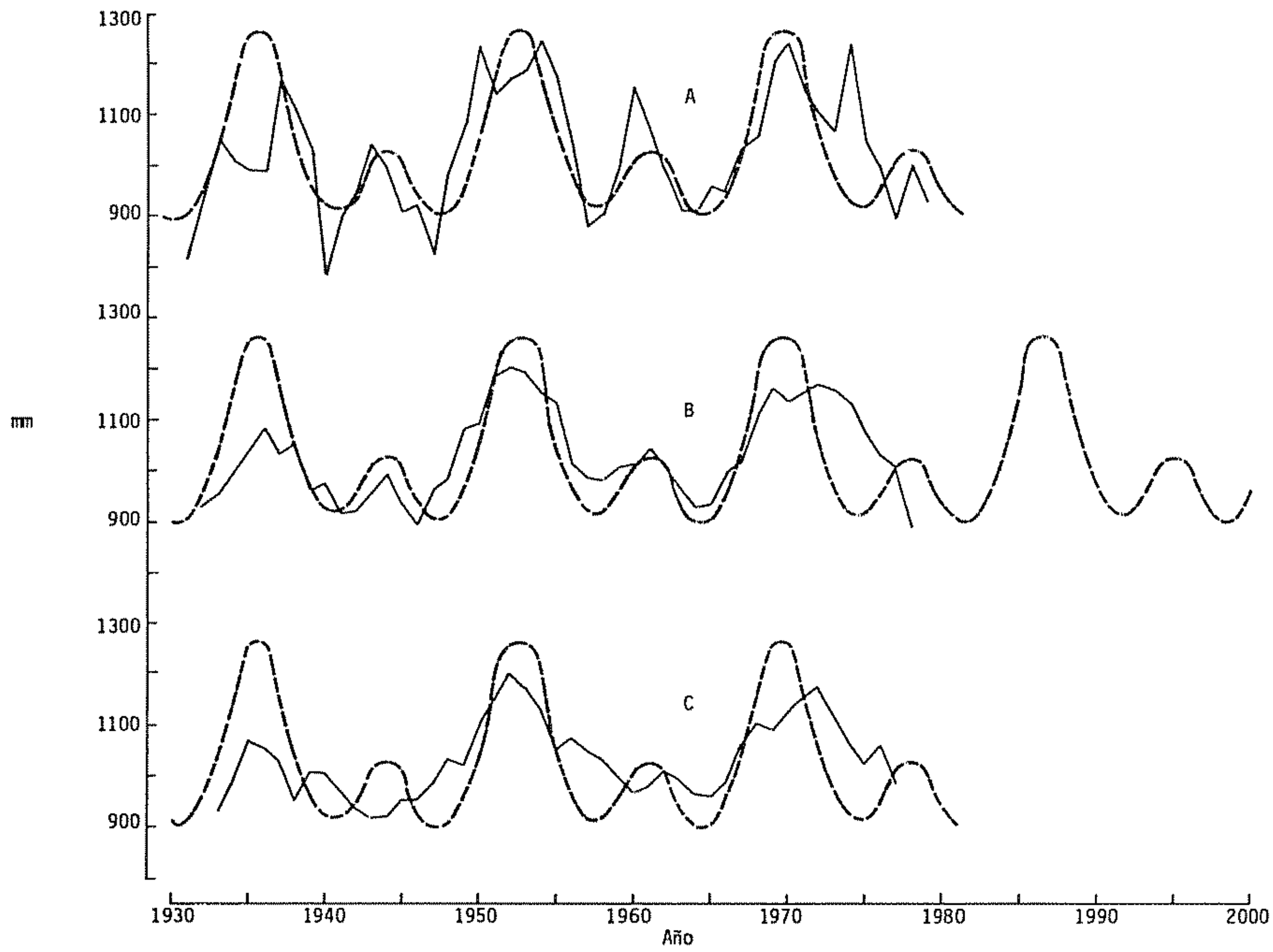

Fig. 7. Tendencia general y promedios móviles de tres (A), cinco (B) y siete (C) años en Palmira (1930–1980).

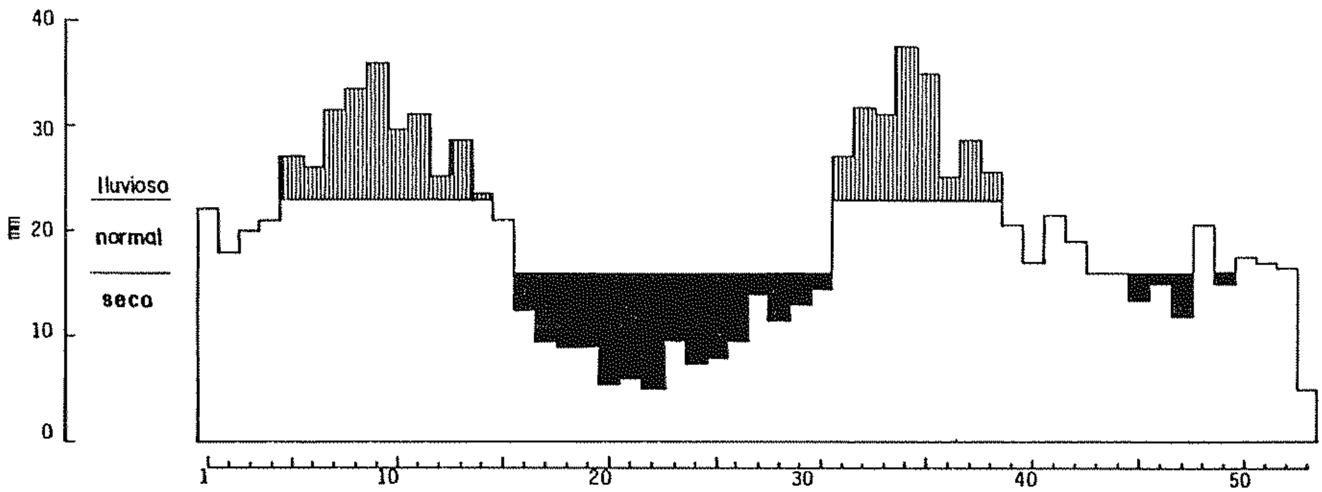

Fig. 8. Distribución normal de la precipitación por períodos semanales en Palmira (1931–1980).

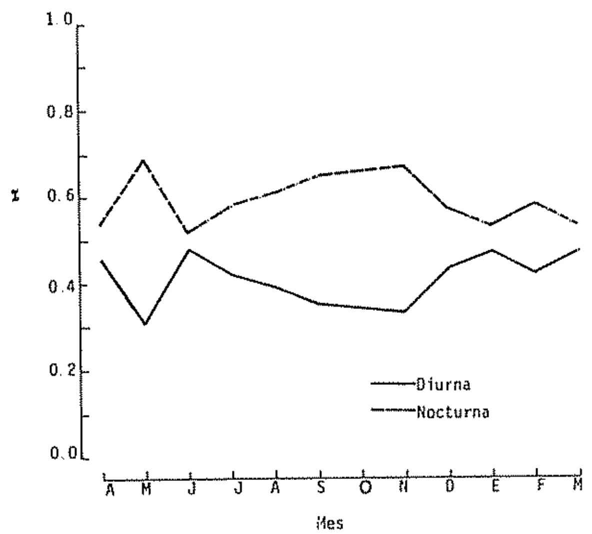

Fig. 9. Precipitación diurna y nocturna (%) en Palmira (1969–1980).

tal vez, porque el lapso analizado en este artículo es más amplio.

En el anterior ordenamiento, los meses que presentan anexa la misma letra indican que, sus promedios mensuales no son significativamente diferentes al nivel de probabilidad de 5% (Análisis de Varianza y Método de Duncan).

En general, se observa que aproximadamente el 87% de la precipitación mensual fluctúa entre 0 y 150 mm/mes.

La frecuencia media de días con precipitación es 133 por año (lluvias ⩾ 0.1 mm/día), sin advertir que en el período de veinticuatro horas (07:00 – 07:00) han podido ocurrir una o más lluvias.

En la Figura 10 se observa que las precipitaciones con cantidad inferior a 2.5 mm/día ocurren con gran frecuencia (58 días/año), pero en promedio este valor apenas asciende a 55 mm/año (aproximadamente el 6% de la lluvia anual).

La mencionada cantidad de lluvia (P < 2.5 mm/día) se evapora muy rápidamente, debido a que ésta humedece únicamente una capa muy superficial del suelo y solo equivale al 50% de la evaporación potencial promedia (2). En consecuencia, tales precipitaciones no interfieren la actividad agrícola.

Considerando los periodos comprendidos entre abril-julio y octubre-enero (Figura 11), que son las épocas en que varios cultivos semestrales requieren agua, se observa que las fluctuaciones de la precipitación en las dos épocas son muy similares (197 a 643 mm/sem. A vs. 210 a 652 mm/sem. B). En el segundo semestre hay mejor distribución y la frecuencia de lluvias con cantidad superior a 410 mm[1] duplica la del primero (48 vs. 24%), lo cual permite que los cultivos sufran menos por deficiencia y haya una mejor productividad.

La precipitación en los dos semestres no es significativamente diferentes (360 vs. 400 mm) en el nivel de probabilidad del 5%. En el Cuadro 1, se presentan las cantidades extremas anuales y mensuales, al igual que las máximas diarias de precipitación.

Conclusiones

Los días lluvia han tendido a aumentar con el paso de los años.

Existe una periodicidad en la precipitación de 16.67 años, además de otras de 4.54 y 2.17. Sin embargo, son necesarios muchos más datos (al menos 100 años) para confirmar la presencia de dichos ciclos.

El promedio móvil de cinco años es la longitud de periodo más indicada para el análisis sencillo de series pluviométricas en esta región.

1 Equivale aproximadamente al 73% de la evaporación potencial.

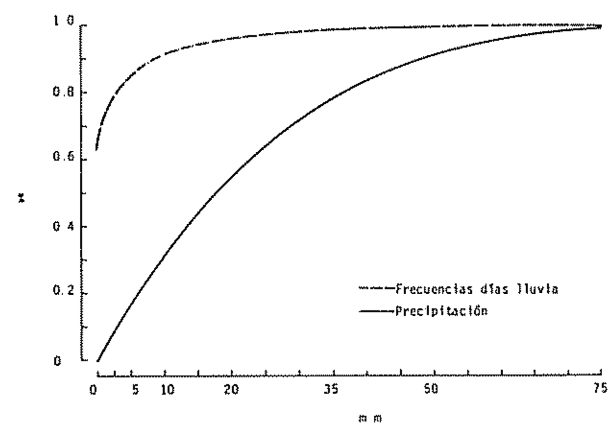

Fig. 10. Precipitación y frecuencia de días con lluvia acumulada (%) en Palmira (1931–1980).

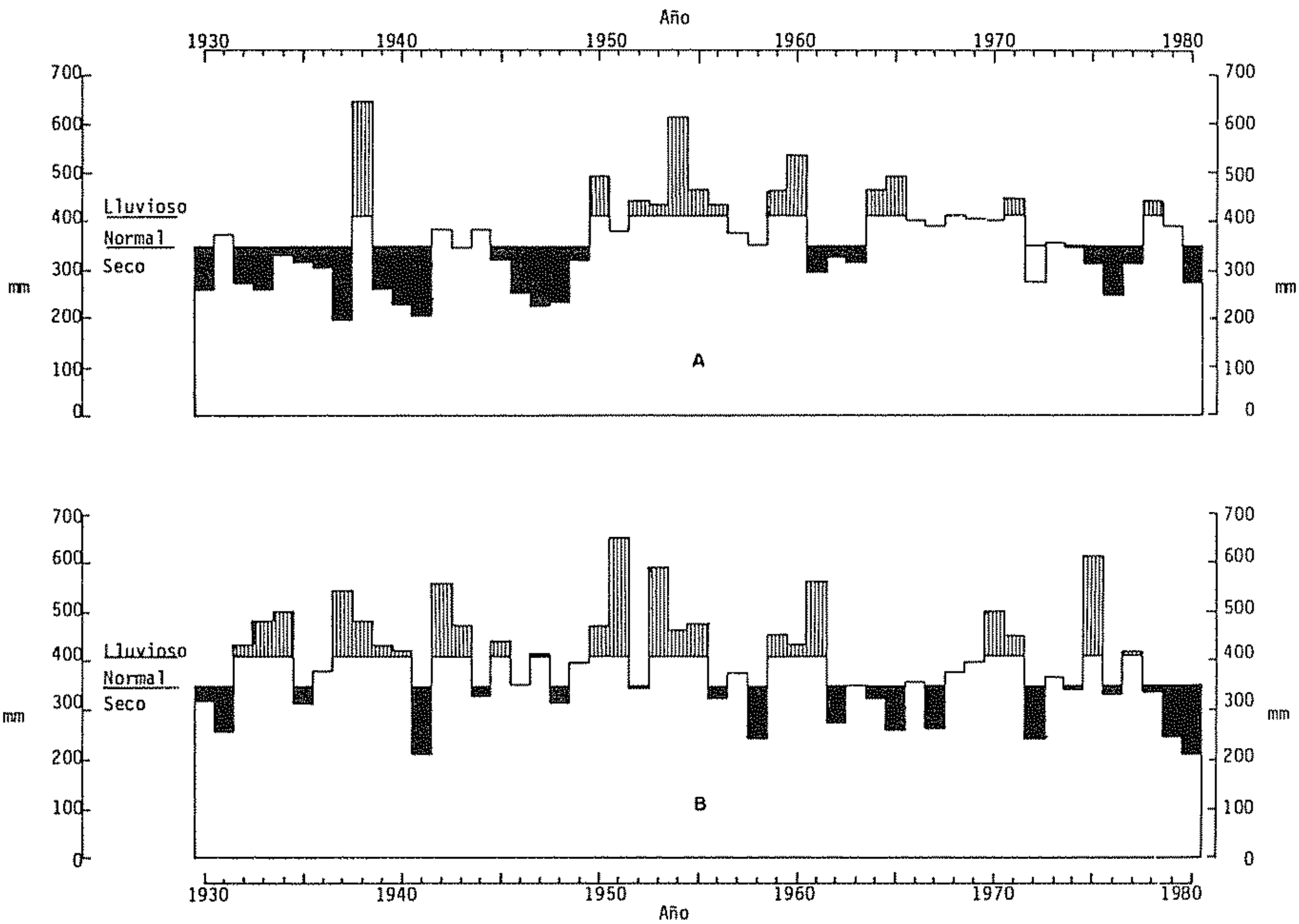

Fig. 11. Totales de precipitación durante (A) primer (Abril- Julio) y (B) segundo semestre (Octubre-Enero) en Palmira (1930-1980).

Los métodos utilizados para hallar periodicidad presentan una buena coincidencia en sus respuestas.

Los resultados obtenidos sugieren un período de abundante lluvia entre los años 1985 y 1988.

La distribución bimodal que ofrece la precipitación, facilita la realización de dos cosechas por año en algunos cultivos de corto período vegetativo.

Las cantidades de precipitación en las dos épocas que los cultivos semestrales requieren agua son iguales, pero hay mejor distribución en la segunda.

Las lluvias en esta región son de origen local.

Resumen

Se realizó un análisis estadístico y matemático de datos pluviométricos de la ciudad de Palmira para el período de 1930 a 1980, con la finalidad de estudiar algunas de sus características, tales como tendencias de duración y periodicidad.

Se observó una importante tendencia alcista en el número de días de lluvia por año a través del período. La distribución de lluvias anuales manifestó un ciclo de 17 años, pero el tamaño de la muestra es tan pequeña que no permite establecer la periodicidad verdadera.

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STUDIES OF VARIATION IN CENTRAL AMERICAN PINES PUTATIVE HYBRIDIZATION BETWEEN *Pinus caribaea* var. *hondurensis* and *P. oocarpa* II[1] */

*B. T. STYLES***
*J. W. STEAD***
*K. J. ROLPH***

Resumen

Con frecuencia se ha sugerido que Pinus caribaea *var.* hondurensis *(Sénécl.) Barr. y Golf. y* P. oocarpa *Schiede, dos especies muy importantes en los bosques tropicales, podrían hibridizar en algunos lugares de Centro América en los que su área de crecimiento natural coincide. En este artículo se presentan los resultados de un estudio detallado, diseñado para investigar este tema en profundidad. Se escogió un lugar en Honduras, en donde las dos especies crecen juntas y se recogió material de 80 árboles a lo largo de una sección transversal en una zona de mezcla. El estudio del material y el análisis de gran número de mediciones por diversos métodos, han revelado la presencia de algunas formas intermedias. Estas se interpretan provisionalmente como híbridos pero la confirmación queda pendiente de los resultados de experimentos de polinización controlada.*

1 Received for publication in July 1980.

* Paper I in this series was published in Silvae Genetica 25(3-4):109-117 (1976).
Post-Scriptum
During the protracted period in which this paper was being revised for publication, considerable work has been carried out on the genetical relationships between these two species. Successful artificial hybridasation between them has now apparently been achieved in both Queensland (Australia) and Honduras (*C. America*) hopefully vindicanting the results of this field study. F_1 hybrids already show faster growth than either of the two parents. Isozyme analysis of putative hybrid seed is being undertaken to confirm hybridity.
We would like to express our thanks to the many people who have assisted us in this study. Our colleagues Mr. G. Chaplin and Mr. A. Greaves, and Mr. W. L. Mittak, INAFOR/FAO, Guatemala, Prof. A. Molina R., EAP, El Zamorano, Honduras and Mr. M. Robbins ESNACIFOR, Siguatepeque, Honduras provided information on the species in the field and material used in the study. Mr. M. Taylor helped with the often tedious job of measuring the material and Dr. C. Green and Mr. B. Keeble analysed the resin samples. Considerable advice on the analysis of the results was freely given by Mr. H. L. Wright, Mrs. J. Stone, Prof. G. Namkoong and Dr. J. Burley. Mrs R. Wise did the drawings, Mr. A. Allen took the photographs, Mrs. Coral Taylor and Mrs. Cynthia Styles typed the manuscript.

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Introduction

The importance of *Pinus caribaea* Mor. including variety *hondurensis* (Sénécl.) Barr. & Golf. is indicated by the very large scale on which it is grown commercially outside its natural area of distribution. It is among the four five most important timber trees at present in cultivation in softwood plantations in the tropics. Though not grown so widely as yet, *P. oocarpa* Schiede is being increasingly planted, and both species will probably assume even greater importance after selection and breeding have produced better adapted genotypes with improved commercial characteristics. Both taxa are included in the Central American pine provenance research programme being conducted by the Unit of Tropical Silviculture at the Commonwealth Forestry Institute, Oxford*, as part of the FAO global programme for the improved use of genetic resources (Kemp 18, 19; Styles, 28; Greaves, 14; Greaves and Kemp, 16; and Greaves 15).

Although both are currently accepted as good Linnean species with different ecological requirements and are classified in quite different subsections of the genus *Pinus*, *P. caribaea* and *P. oocarpa* are nevertheless sometines difficult to distinguish botanically. Where the two grow together their similarities, and the overlap in their variation patterns, are such that a number of observers in Central America have suggested the possibility of hybridization. Botanical specimens showing intermediate morphological characters have been collected on numerous occasions.

Bearing in mind the commercial potential of the two species, and the experimental work now in progress, uncertainty about variation patterns and the possibility of hybridization is a major problem. In order to clarify this a detailed investigation of certain trees growing in a mixed population of the two species in the Republic of Honduras, Central America was carried out. A number of characters, mainly those of needle and cone morphology which have long been found by taxonomists to be useful in distinguishing between taxa in the genus were examined on herbarium specimens, together with a limited amount of chemotaxonomic information obtained from resin. The data obtained were analysed using a variety of established computer and pictorial techniques. The results have revealed the presence of genuine intermediates. These intermediates may represent natural interspecific hybrids, introgressants or perhaps extreme morphological deviants of either of the two parents. The artificial cross between the two species is now being attempted in several tropical countries (Nikles, Queensland, Australia and Houkal, Honduras, Central America, personal communications).

Geographical range and Ecology

P. oocarpa is a very widespread and common species and has the largest area of distribution of any Mexican or Central American pine, ocurring almost continuously from lat. 28° 20'N in the States of Sonora and Chihuahua, Mexico (Martínez 25, Loock, 23), and throughout Central America as far as lat. 12° 40'N in the Departament of Leon, Nicaragua. It is essentially sub-montane, growing between 700 and 1500 m, on steep mountain slopes with good drainage and within a rainfall range of 700-1500 mm. (Kemp, 18). *P. caribaea* var. *hondurensis* has a more disjunctive distribution in Central America, occurring very locally in Mexico (Quintana Roo, approximate lat. 18° 05'N, long. 88° 35'W, Stead and Styles, unpublished information), Belize, Guatemala and El Salvador. Further south in the Honduran Republic and in Nicaragua its range is more extensive and here there is considerable overlap with *P. oocarpa* at intermediate altitudes (Figure 1). In contrast to *P. oocarpa* it is a tropical or subtropical lowland species, found from sea level to 800 m with a few populations extending up to 1000 m. Further detailed accounts of its taxonomy, ecology and distribution are given by Barret and Golfari (3), Loock (23) Luckhoff (24), Nikles (27) and Lamb (21).

Botanical variation and classification

The number of differentiating characters which can be used to distinguish between *P. oocarpa* and *P. caribaea* is small and the fact that these characters are themselves extremely variable makes their identification in the forest and in the herbarium difficult at times. The most important botanical differences between the two species are summarized in Table 1.

P. caribaea and *P. oocarpa* are presently classified in different subsections of the genus *Pinus* (Little and Critchfield, 22). Caribbean pine is placed in the subsection Australes Loud., 'southern yellow pines," and is the only one of the group to extend into Central America. It has 2-3 needles per fascicle with internal or medial resin canals; the female cone is

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* Instituto Nacional de Investigaciones Forestales, Mexico, is cooperating with this programme and is responsible for seed collections of *P. oocarpa* in that country. Seed of 36 provenances has so far been obtained for distribution in the near future, and more collections are being organised (12)

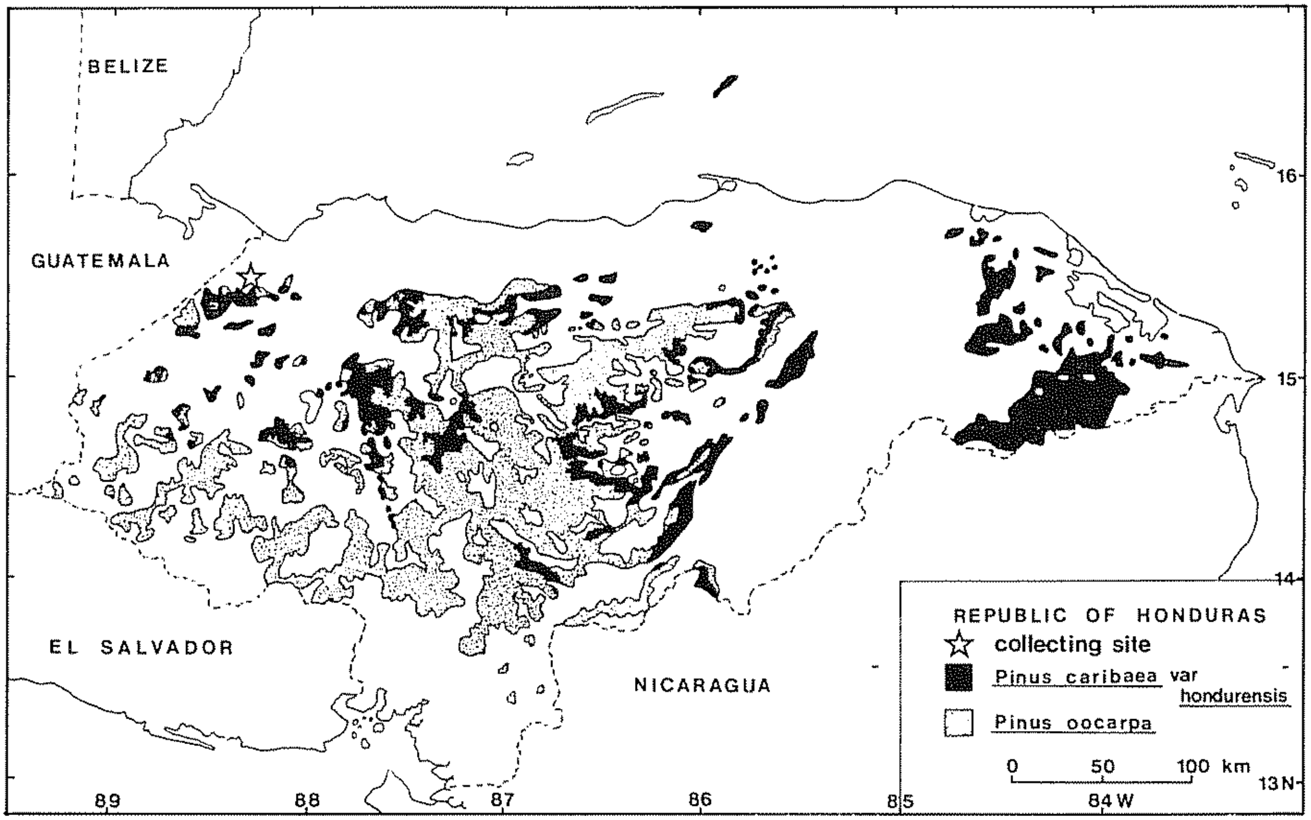

Fig. 1. Map of Honduras Republic showing the distributions of *Pinus oocarpa* and *P. caribaea* var. *hondurensis* and location of collecting site

Table 1. Summary of the chief botanical differences between *Pinus caribaea* var. *hondurensis* and *P. oocarpa*

Character	*Pinus caribaea* var. *hondurensis*	*Pinus oocarpa*
Needles	Fascicles with groups of 3 (sometimes 4, very rarely 2 or 5); needles stiff, thick, erect; drying light green.	Fascicles with groups of 5 (sometimes 3 or 4, rarely 6); needles stiff, sometimes slender, erect or spreading; drying dark green.
Number and positions of resin canals	Generally 2-3 (4); usually all internal, sometimes with 1 or 2 medial. (Higher numbers recorded by Lückhoff (24) for other varieties).	Generally (3)4-5(6); mostly all septal, or with 1-2 external, or less frequently 1-2 medial or internal.
Female cone (open)	Broadly elongate, cylindrical to elongate, ovoid (barrel shaped); symmetrical or slightly asymmetrical; markedly deciduous, falling without peduncle; reddish brown, turning dark dull brown to black.	Broadly ovoid, sometimes conoidal (egg-shaped); opening in the form of a rosette; slightly asymmetrical; with a stout peduncle; long persistent on tree after maturity; tawny-brown, shining.
Cone scales	Softly woody, thin and flexible; widely spaced; apophysis raised, sometimes recurved, keeled, rugose; umbo raised with a short persistent prickle.	Very woody and thick; compact; apophysis flat or convex, keeled, smooth; umbo often prominent and raised, sometimes prolonged; prickle deciduous.

asymmetrical (oblique) and persists on the tree for a long time after maturity; the cone scales remain closed for a considerable time and open irregularly and slowly over an extend period to release the seeds (serotinous); they generally possess a prickle (often deciduous), or sometimes a protruding umbo.

Hybridization

Hybridization between species in different subsections is rare among the pines, but not unknown, (Critchfield, 8, 9; Barnes, 2), which makes the supposed cross between *P. oocarpa* and *P. caribaea* all the more interesting. Nevertheless, many botanists and foresters with field experience in the Central American pine forests believe that these two do intergrade or hybridize in certain areas [Williams, 29; Denevan, 11; Barrett and Golfari, 3; and Luckhoff, 24)]. Such hybrids occur in areas of "intermediate' altitude between 500-700 m where trees of the two grow in intimate mixture. The characters of the intermediate forms cannot be due to environmental conditions. *P. oocarpa* specimens have been studied (by BTS) from trees growing as low as 200 m in Mexico and *P. caribaea* var. *hondurensis* has been investigated at 900 m in Guatemala. Specimens from 'extreme' altitudes were typical in all respects of cone morphology and needle anatomy. Over most of their range the two taxa apparently remain distinct (Coyne & Critchfield, 6; Styles, unpublished).

Natural hybridization in some zones of overlap appears possible on biological grounds since flowering times sometimes coincide. Although the main peak periods of pollen shedding and female conelet receptivity are different in the two species, in some areas in Central America there is considerable overlap, and occasional trees of both species can be found at the same time with receptive female cones and/or mature flowers with well formed pollen. Phenological observations in so far as they have been made suggest that *P. caribaea* var. *hondurensis* sheds the main bulk of its pollen earlier than *P. oocarpa*, and Critchfield (7) noted in mid-January 1965 that trees in populations of both species in Honduras had mostly or completely shed their pollen by this time. Robbins* visited the experimental area at Pinalejo, from where the study material was obtained (see below) in mid-November 1977, and noted then that some trees of *P. caribaea* var. *hondurensis* there had mature male and receptive female flowers (strobili) with many more still developing. On some other trees the male flowers had finished shedding their pollen and newly fertilized female cones were already developing. *P. oocarpa* was later in development with the male flowers present as 3-4 mm long buds, but some more or less symmetrical, quickly deciduous, with scales which all open more or less simultaneously at maturity. The scales generally possess a persistent prickle or apiculus.

P. oocarpa is placed with the closed-cone pines, in subsection Oocarpae, which consists of seven species confined to the southern United States, Mexico and Central America. The group is characterised by having the leaves in fascicles of 2-5, with medial, internal or septal resin canals; the female cone is mostly female conelets were however at the receptive stage. Local environmental conditions are thought to be responsible for the wide variations noted by field workers regarding the flowering times of the two.

Materials and methods

In order to investigate the possibility of naturally occurring hybrids between these two pines are fully, one of the intermediate zones was chosen for special study. Following advice from the staff of the Banco de Semillas, ESNACIFOR, Siguatepeque an area in Honduras was selected. This lies in the Department of Santa Barbara near the village of Pinalejo (lat. 15° 23'N, long. 88° 23'W), between 300 and 900 m altitude, on the southern slopes of the Sierra de Espiritu Santo (Figure 1). The terrain is one of open pine forest which has been logged in the past, but which has suffered relatively little human interference since. The stands contain trees of all ages and a number of large malformed specimens of both species still remain. At lower altitudes, forest with only *P. caribaea* var. *hondurensis* occurs passing through a transition zone where it grows in mixture with *P. oocarpa*. At higher elevations trees of the latter occur as the only species, but these in turn give way to forest of pure *P. tenuifolia* Benth. (= *P. maximinoi* H. E. Moore) at and above 1500 m. Within the transition zone (altitudes between 500 and 700 m) trees are found which cannot be satisfactorily identified as either *P. oocarpa* or *P. caribaea* var. *hondurensis*, a number showing characteristics intermediate between the two. Furthermore, some specimens appear to possess foliage typical of *P. caribaea* var. *hondurensis* and mature female cones resembling more those of *P. oocarpa*. The reverse situation is also true.

A transect was made through the forest from a low elevation of approximately 400 m with trees of pure *P. caribaea* only, passing through a zone of mixture

* Mr. M. Robbins of the Banco de Semillas, Escuela Nacional de Ciencias Forestales (ESNACIFOR). Siguatepeque, Honduras.

and reaching forest of pure *P. oocarpa* at approximately 900 m. Along the transect eight sites were selected at approximately 75-100 m intervals, and within each site ten mature trees were chosen at random (Table 2).

For each tree two foliage samples were collected from the crown, together with four mature, open female cones. These samples were selected at random within the crown, to represent each tree. No effort was made, in this study, to examine the pattern of within tree variation.

A small (7 cm^3) bottle was screwed into the base of the bole and a sample of resin collected overnight. Thus from each of ten trees at eight sites fully correlated botanical material consisting of two herbarium specimens, four cones and a sample of resin was available. The morphological characters assessed are listed in Table 3 (see also Figures 2a, b, c and d).

Analyses and results

Various methods for the analysis of this type of data have been used and have been critically appraised in papers by Namkoong (26) and Goodman (13). Dancik and Barnes (10) recommend, for the analysis of hybrid populations, sequential use of various methods *e.g.* Principal Components Analysis Discriminant Analysis and Canonical Analysis, in order to produce a detailed picture of the relationships between taxa and their relative variability.

Numerous analyses were performed in an effort to reveal the pattern of relationships between the individual trees included in this study. Each analysis contributed something to our understanding of the data but it would be cumbersome and confusing to present all of them here. The results of analyses using two different techniques are shown below. It was felt that, of all the multivariate techniques used, canonical correlation analysis (CCA) most clearly demonstrated the taxonomic relationships within the material, and the results of this analysis are shown below. Also included are the results of analyses using the Pictorialised Scatter Diagram technique developed by Anderson (1). This is a much simpler method and it is interesting to compare the results of the two different analyses.

Canonical Correlation Analysis (CCA): Canonical correlation analysis was developed to investigate the relationship between two or more sets of variables. The method used is to calculate the principal components of each set and then to correlate the resulting components. For a summary of the origins and theory of the analysis and the terminology used, see Jeffers (17).

In this case the two sets of variables are cone characters and needle characters. A CCA will therefore reveal the relationship between the individuals in the analysis in terms of the variation in their cone and needle characters.

That the type of measurements made could be used to separate individuals from two taxa into their respective groups by this type of analysis was demonstrated using data from two isolated and presumably pure parent populations. Material from 25 trees (numbered 1-25) from a pure stand of *P. oocarpa* at La Lagunilla, Guatemala (lat. 14° 42'N, long. 89° 57'W) and from 25 trees (numbered 26-50) from a pure stand of *P. caribaea* var. *hondurensis* at Alamicamba, Nicaragua (lat. 13° 34'N, long. 84° 17'W) were measured for the characters listed in

Table 2. Location of trees within sites.

Site	Species	Altitude (m)	Tree Number
1	*P. caribaea* var. *hondurensis*	395 – 410	1 – 10
2	*P. caribaea* var. *hondurensis*	445 – 475	11 – 20
3	*P. caribaea* var. *hondurensis*, *P. oocarpa*, and *intermediates*	500 – 535	21 – 30
4	*P. caribaea* var. *hondurensis*, *P. oocarpa*, and *intermediates*	585 – 600	31 – 40
5	*P. caribaea* var. *hondurensis*, *P. oocarpa*, and *intermediates*	660 – 680	41 – 50
6	*P. oocarpa*	700 – 710	51 – 60
7	*P. oocarpa*	795 – 810	61 – 70
8	*P. oocarpa*	890 – 910	71 – 80

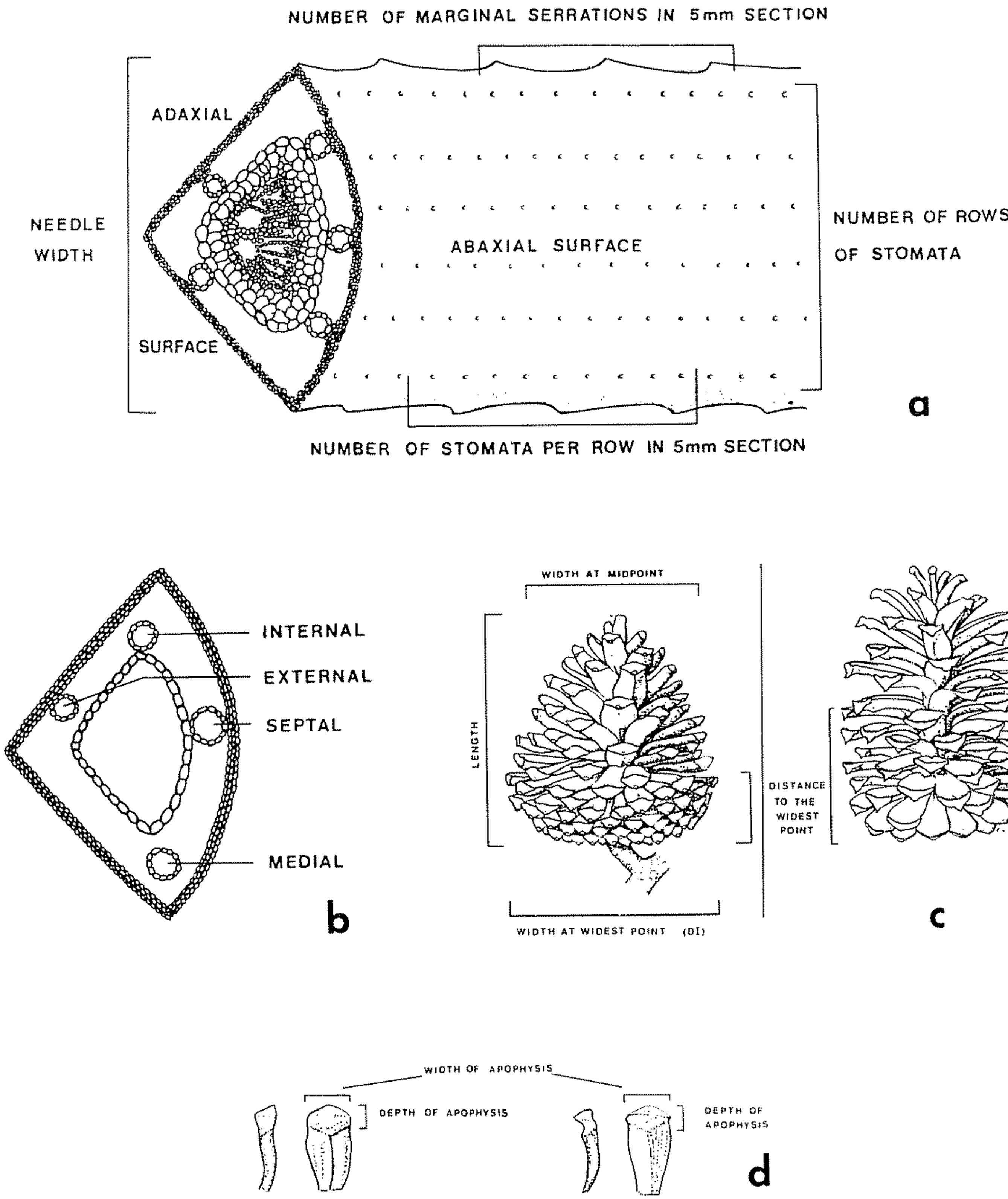

Fig. 2 Diagrams to show the characters measured: a. Part of a needle; b. Cross section of a needle; c. Cones; d. Cone scales

Table 3. Only one herbarium specimen and two cones per tree were available in this study.

In this application we were not interested in within tree variation so that for each character, tree means were calculated for use in the analysis. We have assumed for the purposes of this technique, that the data are approximately multivariate normal. This would seem to be reasonable particularly in the light of previous work (Cotton *et al.* 5; and Dancik and Barnes, 10). Problems arising from the use of different scales in the assessment of characters were circumvented by using the correlation matrix.

A CCA, was carried out and five roots were estimated. The first, which accounted for 41.4% of the variation, had a canonical correlation coefficient of 0.9755 (significant at 0.1% by Bartlett's test). None of the remaining four was significant and they will not be considered further. Table 4a gives the canonical vectors for the first pair of canonical variables. Note that the vectors have been scaled (the largest set to 1.0 with the others in proportion) to make them easier to interpret.

It is apparent from the table that of the needle characters, the number of needles per fascicle, with

Table 3. Characters used in the analyses.

Needle characters

Characters 1 – 3 were assessed on 5 mature fascicles from each of the two herbarium specimens per tree (i.e. 10 fascicles).

1. Number of needles per fascicle.
2. Fascicle sheath length (to the nearest 0.5 mm).
3. Needle length, of the longest needle in each fascicle (to the nearest 0.1 cm).

Characters 4 – 8 were assessed on a 5 mm section from the central portion of the longest needle, from each of the 10 fascicles used for 1 – 3. (Figure 2a).

4. Needle width (x40), measured with a stage micrometer (to the nearest 0.1 mm).
5. Number of rows of stomata on the adaxial surface.
6. Number of rows of stomata on the abaxial surface.
7. Number of stomata per row counted on the abaxial surface (the most easily defined row of stomata was chosen).
8. Number of marginal serrations counted along one side

Characters 9 – 12 were assessed on hand sections, cleared in fuming lactic acid, cut from the central portion of the needles used for characters 4 – 8 (Figure 2b).

9. Number of external resin canals
10. Number of internal resin canals.
11. Number of medial resin canals.
12. Number of septal resin canals

Cone characters

Characters 13 – 17 were assessed on the four cones per tree to the nearest 0.1 cm using a metal gauge (Figure 2c).

13. Cone length.
14. Cone width at the widest point, DI.
15. Cone width at 90° to DI, i.e. DII.
16. Distance to the widest point i.e. from the base of the cone to the point at which DI was taken.
17. Cone width at the mid point.

Cone scale characters

Characters 18 – 19 were assessed on 5 scales from each of the 4 cones per tree, to the nearest 0.25 mm using calipers (Figure 2d).

18. Width of apophysis.
19. Depth of apophysis.

Note: The data are not reproduced here but are filed on specially prepared proformas and are available at Oxford.

a vector score 1.0000, is the most important. None of the others makes any sizeable contribution, and consequently we consider that the first canonical vector represents essentially "needles per fascicle".

For the cone measurements, the vector expresses mainly the width at the widest point (DI) (score 1.0000), contrasted with the width taken at right angles to DI (i.e. D II) (score –0.4447). This would seem to be an expression of both "basal shape" and the "degree of symmetry" of the cone. It is interesting that the degree of symmetry could be an important taxonomic character and, whilst it is difficult to observe and quantity, it has been highlighted by this analysis.

The results for the first pair of canonical variables. are presented in Figure 3. This graph shows a well-defined partition of the 50 individuals into two species groups on the basis of this first pair of canonical variables. Note that *P. oocarpa* is characterised by high values for 'Needles per fascicle' and 'Basal shape and symmetry of cone' whilst *P. caribaea* var. *hondurensis* is characterised by low values for the same 'character.'

The same analysis was then carried out using data from the 80 trees collected in the transect study. Of the five roots estimated, the first two accounted for 39.3% and 22.9% of the variation respectively and had canonical correlation coefficients, of 0.8215 and 0.6277 (significant at 0.1% by Bartlett's test). The canonical vectors for the first two pairs of canonical variables are given in Table 4b. Looking at the needle characters for the first pair, it appears that the number of stomatal lines on the abaxial surface is most important (score 1.0000), contrasted with the number of septal resin canals (score –0.4528). In the case of the cone characters it is again a measure of cone basal shape but this is contrasted with depth of the apophysis (score –0.7679).

Although the second canonical correlation was significant, a plot of individual tree scores did not show any separation even between species. This shows that there is some pattern of variation within the data independent of the accepted division into two taxa. As we have accepted the division into two species, and are looking for possible intermediates between them this part of the analysis is of no value and will not be considered further.

A graph plot of the first pair of canonical variables is shown in Figure 4. It can be seen here that the individuals have been separated into two groups representing *P. oocarpa* and *P. caribaea* var. *hondurensis* very much as was observed in Figure 3. The interesting feature is that ten trees are found, with varying degrees of intermediacy between the two main groups. These ten trees, numbers 19, 23, 27, 30, 36, 37, 38, 48, 50, 61 are almost all from the "intermediate" altitudinal zones and the herbarium specimens collected were labelled as "possibly hybrid" by one of the authors (Styles).

Comparing Figures 3 and 4 it will be noted that different sub-sets of the characters are involved in the separation of the individuals in the two analyses. In explaining this it must be remembered that CCA was performed 'independently,' on the data from the pure parent populations and the data from the transect, to reveal the relationship between individuals in terms of variation patterns in cone and needle characters. The fact that a more extensive and different sub-set of characters is significant in the transect analysis, is due to the greater variation in these data introduced by the presence of intermediates. Thus, for example, difference in needle number is no longer sufficient to discriminate between the two species and two other characters ("Rows of stomata on abaxial surface/Number of septal resin canals") largely account for the separation.

Pictorialized Scatter Diagram: In this analysis a reduced number of characters was used, to avoid undue complexity. Three were combinations of characters used individually in the canonical correlation analysis. Table 5 shows the characters used and

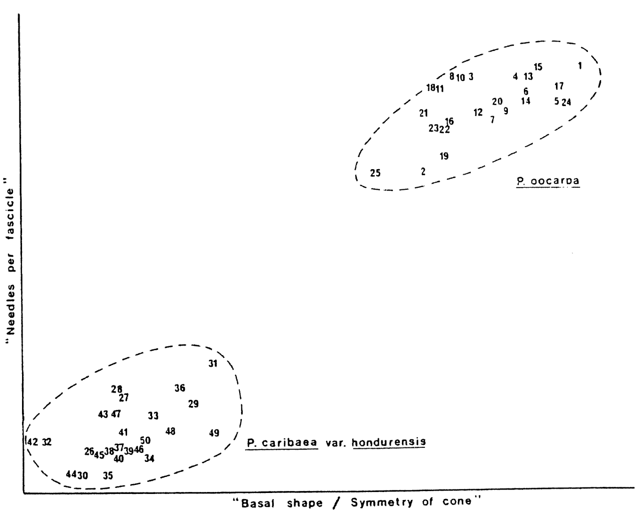

Fig. 3. Canonical correlation Analysis of two pure parent populations (*P. oocarpa* (Guatemala) & *P. caribaea* (Nicaragua)): graph of canonical vector scores for root 1.

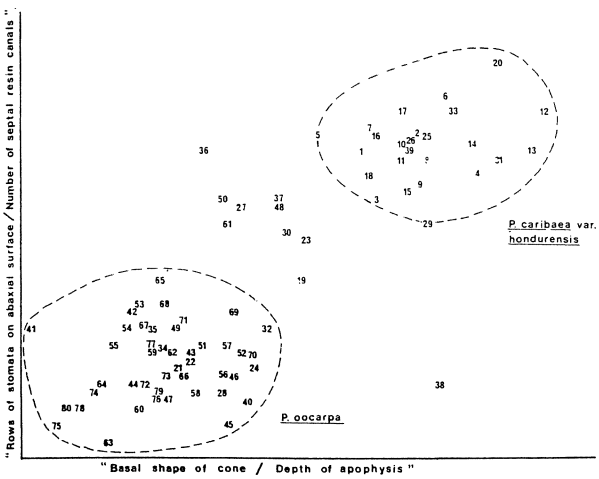

Fig. 4. Canonical Correlation Analysis of 80 trees from the transect study: graph of canonical vector scores for root 1.

how they are represented. Two characters, number of needles/fascicle and cone shape, were chosen as the axes of the graph as multivariate analyses had previously indicated that they were the most valuable for distinguishing the species. Their range of variation was divided into ten classes, and each individual tree was plotted on the graph according to its score. The other characters were incorporated on the graph using the designated symbols (Table 5).

The result in shown in Figure 5 where it can be seen that the scatter produced is very similar to that of Figure 4. On the diagram, 80 individuals from the transect study have been divided into two groups representing the two species, plus several individuals which occupy intermediate positions. More about the characteristics of the two main groups and the intermediates can be determined from the axes and the symbol combinations.

Some of the individuals on the diagram have been marked with numbers, equivalent to those used in the CCA and Figure 4. Those occupying an intermediate position are numbers 3, 5, 19, 23, 27, 29, 30, 31, 36, 38, 48, 61. This list compares favourably with that derived from the CCA. Four trees, 3, 5, 29 and 31, are included which were considered to be "parent" types in the CCA. Two trees, 37 and 50, which were intermediate on the CCA analyses are here placed in the parent groups.

Discussion and conclusions

This project was designed as a detailed study of a number of pine specimens from a restricted area of Honduran forest. The specimens studied had been collected from along a transect to include, as far as possible, all the types present, and in the study of

Table 4. Canonical Correlation Analysis of (a) two pure parent populations: the canonical vectors of the first pair of canonical variables, and (b) 80 trees from a transect: the canonical vectors of the first two pairs of canonical variables.

	NEEDLE CHARACTERS[1]												
	Needles/ fascicle	Length of sheath	Needle length	Needle width	Rows of stomata abaxial surface	Rows of stomata abaxial surface	Stomata/ row	Serrations	External resin canals	Internal resin canals	Medial resin canals	Septal resin canals
(a)	1.0000	0.1891	−0.0971	−0.0809	−0.0406	0.0396	0.0523	0.0978	−0.0842	−0.0292	0.1177	−0.0488
(b)	−0.2012	−0.1107	0.3775	−0.0830	1.0000	−0.2653	−0.1236	0.2957	−0.1351	−0.0996	−0.2355	−0.4528
	0.8677	−0.7933	−0.0831	1.0000	0.0308	0.5023	0.4463	−0.3064	0.1222	0.1854	0.1058	0.5017

	CONE CHARACTERS[1]						
	Length	Width DI	Width DII	Distance to widest point	Width at the mid point	Width of apophysis	Depth of apophysis
(a)	−0.1634	1.0000	−0.4608	−0.4447	−0.2030	0.2771	0.2812
(b)	0.3836	−0.4956	−0.0162	1.0000	0.3306	0.2984	−0.7679
	−0.0608	−0.6214	1.0000	0.2431	0.0256	−0.0337	−0.1898

1 The parameters were quantified as described in Table 3.

Table 5. Characters, and their score values/symbols, used in the Pictorialised Scatter Diagram (Included in Figure 5).

CHARACTER	SCORE									
Number of needles per fascicle (y axis)	1 ≥4.9	2 4.8–4.7	3 4.6–4.5	4 4.4–4.3	5 4.2–4.1	6 4.0–3.9	7 3.8–3.7	8 3.6–3.5	9 3.4–3.3	10 ≤3.2
Needle length x Needle width	≤19.9		20.0–23.9		24.0–27.9		28.0–31.9		≥32.0	
Number of rows of stomata on the abaxial surface	≤4.9		5.0–6.9		7.0–8.9		9.0–10.9		≥11.0	
Percentage septal + external resin canals	≥71.0				70.9–31.0				≤30.9	
Cone Shape (x axis) — Length x distance to widest point / DI + DII/2	1 ≤1.5	2 1.6–2.0	3 2.1–2.5	4 2.6–3.0	5 3.1–3.5	6 3.6–4.0	7 4.1–4.5	8 4.6–5.0	9 5.1–5.5	10 ≥5.6

these individuals numerous measurements were made and several different analyses performed. Both types of analyses presented here reveal individual trees which are intermediate in morphology, particularly in cone shape, needle number and in their internal needle anatomy, between the two parents.

Two types of analysis were chosen to demonstrate the conclusions, but it must be remembered that all

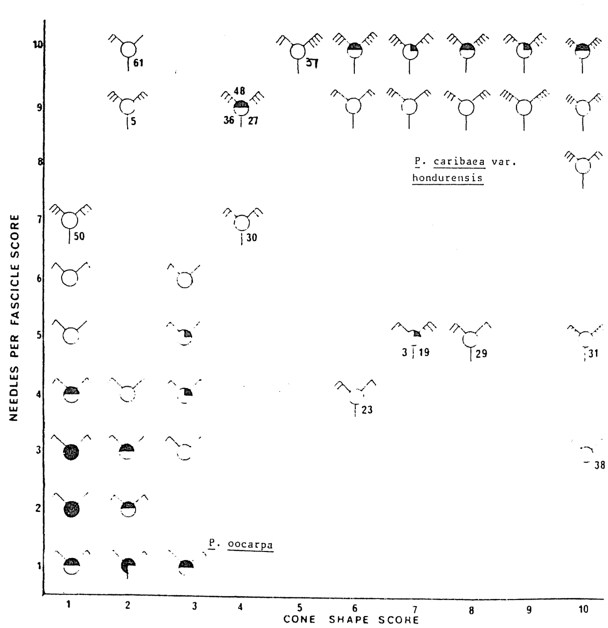

Fig. 5. Pictorialised Scatter Diagram to demonstrate relationship between the 80 individuals in the transect study (see Table 5).

the analyses performed helped to reveal the patterns within the data. It is our opinion that, of these two analyses, the CCA most accurately and clearly separated the individuals into their groups. The simpler Pictorialized Scatter Diagram placed some individuals in the intermediate zone which, according to the CCA and on closer inspection, were considered to be good *P. oocarpa* or *P. caribaea* var. *hondurensis,* and *viceversa.* This simpler method will still be very useful however where more sophisticated computer analyses are not available.

Considering further the characteristics of the intermediates revealed in this study, reference to Figures 4 and 5 demonstrates that cones from these trees are intermediate in form, between the 'egg-shape' of *P. oocarpa* and the 'barrel-shape' of *P. caribaea* var. *hondurensis*. Compare the photographs and diagrams of cones from this study shown in Figure 6. The cones of most of the intermediates resemble those of *P. oocarpa* but are more elongate with rounded (not more or less flat) bases. The cone scales are narrower, more widely spaced and often with a persistent prickle. Similarly there are cones of a *P. caribaea* var. *hondurensis* type which are more ovoid and with a persistent peduncle (a feature not studied in the analyses) as particularly shown in Figure 6d.

Intermediacy is also found in the needle characters e.g. number of needles/fascicle, number of rows of stomata on the abaxial surface and internal anatomy. The intermediates generally possessed fascicles with 3, 4 and 5 needles, with cross-sections showing a

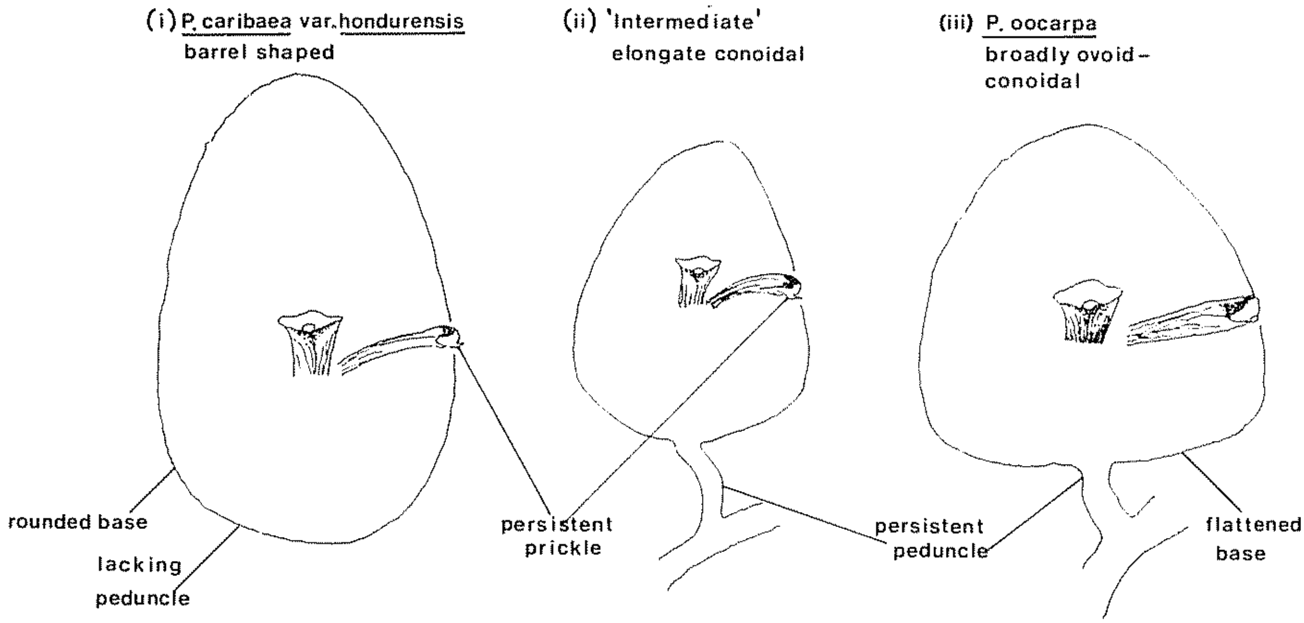

Fig 6. Female cones, (iii): *P. oocarpa*. (ii): 'Intermediate'; (i): *P. caribaea* var *hondurensis*: d: Outlines.

mixture of internal, medial and septal resin canals (Figure 7).

Another point suggested by the analyses is the existence of not only intermediates but also of some individuals with a cone typical of one species and needles typical of the other and *vice versa*. Referring to Figure 4, such types are represented by those individuals tending towards the top left and the bottom right hand corners of the graph. For example tree 38 has needles typical of *P. oocarpa* and cones more typical of *P. caribaea* var. *hondurensis* whilst the reverse in true of tree 36. These trees are probably F_2 transgressants which cannot be considered as mere genetic intergradations.

Further evidence as to the intermediate nature of some of these trees comes from analyses of the correlated resin samples which were collected from each tree.

The terpene composition of each sample was determined by staff of the Tropical Products Institue*. They have studied collections of resin of the two species from all over their range in Central America (Burley and Green, 4). A sample of 20-30 trees is preferred for 'provenance' identification, but results from the transect study were analysed as eight 'provenances' of only ten trees. Each tree was placed in one of a limited number of categories depending on the percentage abundance of six selected terpenes. The percentage of trees in each category was used to define each 'provenance'.

This analysis suggested division of the 'provenances' into the same subjective groups defined at the beginning of the project and listed in Table 2. Most importantly it suggested sites three, four and five were 'intermediate'. Thus on a site basis resin analysis can be used to test for the presence of intermediacy. Unfortunately this is very difficult on an individual tree basis; however a tentative classification of trees in the intermediate zone was made. Of four trees which were found to have unusual resin compositions, three i.e. 19, 30 and 36 are found in the intermediate group in Figure 4. Of the rest of this intermediate group, trees 23, 27, 37 and 50 were labelled as 'uncertain' on the results of resin analysis alone. These results will be published in a more detailed form later.

We therefore interpret these intermediate trees as possible F_1 and F_2 hybrids, but with some reservation since their status can only be confirmed by carefully controlled pollination experiments. There are scarcely any published data on the factors which effect the developmental stages of the leaves and female cones, which still need considerable study. The fertility of such hybrids will need further inves-

* Tropical Products Institute (I.P.I.), 56-62 Gray's Inn Road, London WCIX 8LU.

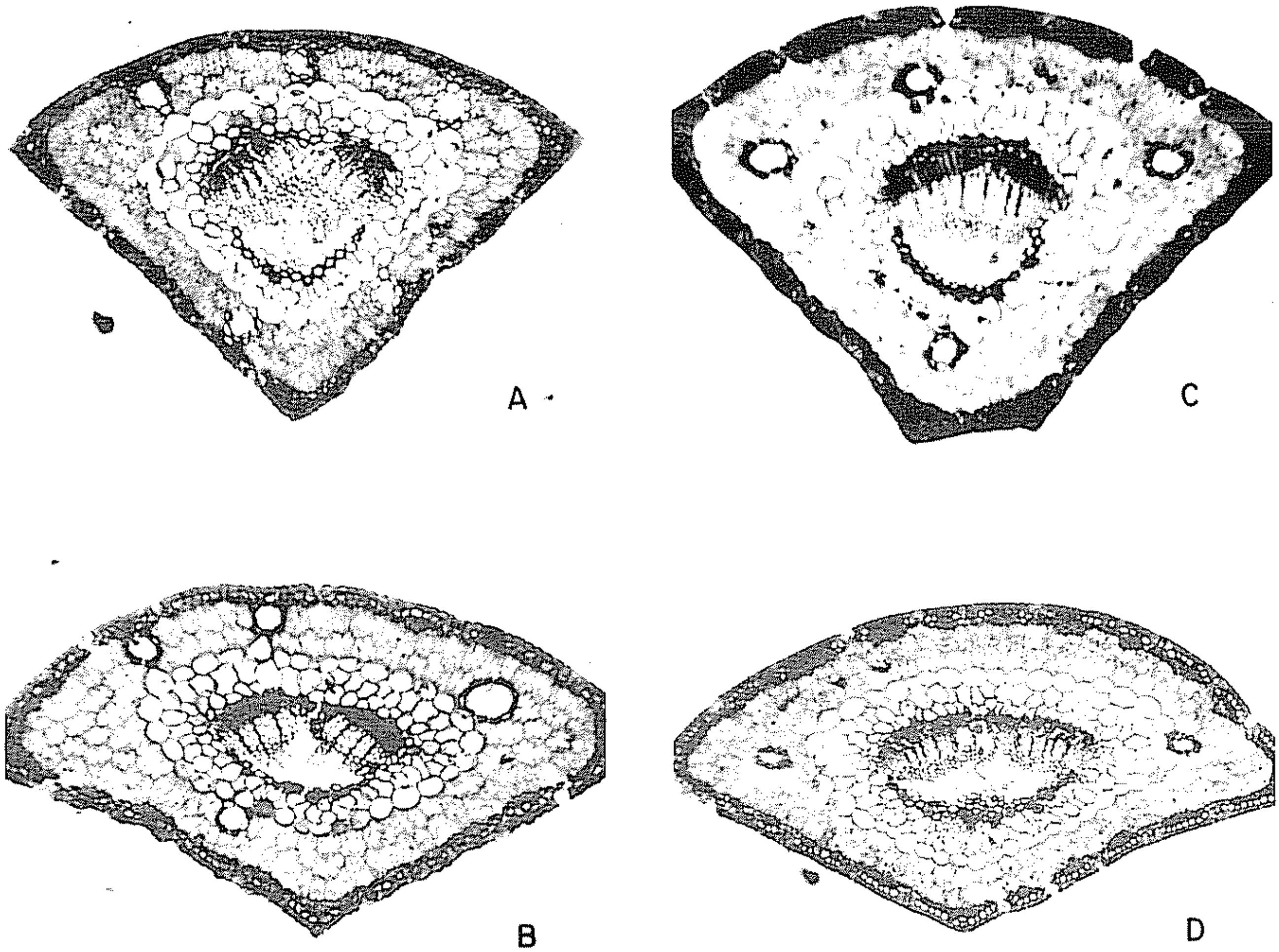

Fig. 7. Cross sections of needles. a(x110): *P. oocarpa*. b (x105), c (x110): 'Intermediate'; d (x90): *P. caribaea* var. *hondurensis*

tigation, since in the present study it is difficult to hypothesise about possible introgression, although some trees in the study certainly suggest this.

Summary

It has been frequently suggested that *Pinus caribaea* var. *hondurensis* (Sénécl.) Barret and Golfari and *P. oocarpa* Schiede, two species very important in tropical forestry, might hybridize in some places where their natural ranges overlap in Central America. In this paper, results are presented of a detailed study designed to examine this further. A site in Honduras was chosen where the two species grow together and material was collected from 80 trees along a transect running through an area of mixture. Study of the material and analysis of numerous measurements by different methods have revealed the presence of some intermediate forms. These are tentatively interpreted as hybrids but confirmation must await the results of controlled pollination experiments.

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EFEITO DE TEMPERATURAS SUPRAÓTIMAS NO SISTEMA RADICULAR, NO CRESCIMENTO E NA ABSORÇÃO E TRANSLOCAÇÃO DE NUTRIENTES, EM CAFEEIROS CULTIVADOS EM SOLUÇÃO NUTRITIVA[1] /*

*COARACY M. FRANCO***

Summary

Coffee seedlings, Coffea arabica *cv. Catuaí, were grown in nutrient solution for a period of six months after germination, in six special containers, with 25 seedlings in each.*

The temperature of the nutrient solution in the containers was kept constant at each of the following levels: 27, 29, 30, 31, 32 and 33 degrees centigrade.

After six months plant height, fresh weight of roots and tops, and their contents in N, P, K, Ca and Mg were determined.

Between 29°C and 33°C the increase of just one degree centigrade in the temperature of the root system resulted in a pronounced decrease in the growth of the plants.

At higher root temperatures the phosphorus and magnesium contents of the root system increased markedly while the reverse was observed in the tops. This seems to indicate that the translocation of those elements from the roots to the tops was adversely affected by the increase of the root temperature.

Potassium was markedly accumulated both in roots and tops at the higher root temperatures tried.

Introdução

Em trabalho anterior (Franco 1) mostrou-se que o cafeeiro é bastante sensível às variações da temperatura no seu ambiente radicular. O melhor desenvolvimento foi obtido de 23°C a 28°C. Na temperatura de 33°C o crescimento do cafeeiro foi mínimo.

Com o objetivo de obter informações mais detalhadas sobre o assunto e estudar também a nutrição mineral em relação a temperatura do sistema radicular, cultivou-se o cafeeiro em solução nutritiva cuja

1 Recebido para publicação em junho 1982.

* Trabalho executado na Seção de Fisiologia do Instituto Agronômico de Campinas, em convênio com o Instituto Brasileiro do Café.
Expressamos os nossos agradecimentos aos técnicos da Seção de Química Analítica, do Instituto Agronômico de Campinas pelas análises minerais executados. Consignamos também nossos agradecimentos aos auxiliares Arlindo Sales Nogueira e Avelino Marion *post morten* pela dedicação e interesse que dispensaram na instalação do experimento e na manutenção do equipamento.

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temperatura foi controlada nos níveis desejados por meio de aquecedores e termostatos.

Material e métodos

Utilizaram-se recipientes de plástico opaco e rígido, com 37 x 53 cm de lado e 20 cm de profundidade que receberam tampas de madeira tratada contra o apodrecimento. Na tampa foram feitos 25 furos equidistantes com 3.5 cm de diâmetro. Em cada furo foi colocada uma plantinha recém-germinada com apenas o par de folhas cotiledonares.

As plantinhas, do cultivar Catuaí, foram fixadas por rolhas de cortiça furadas no meio, que se ajustavam nos furos da tampa. Para a rolha não ferir o caule tenro das plantinhas este era envolto com um pequeno pedaço de esponja plástica.

No interior de cada caixa, a cerca de 2 cm do fundo, foi instalada uma resistência elétrica para o aquecimento da solução nutritiva e a cerca de 3 cm acima da resistência instalou-se um termostato.

Seis caixas foram preparadas da forma descrita, e reguladas para as seguintes temperaturas na solução nutritiva: 27, 29, 30, 31, 32 e 33 graus centigrados.

A solução nutritiva empregada foi a de Hoagland e Broyer (3) que era trocada a cada três semanas. Todos os recipientes recebiam aeração continua.

Nos tratamentos com temperaturas acima de 30ºC o ar antes de borbulhar na solução passava por uma serpentina plana, de aço inoxidável, instalada no fundo dos recipientes, mergulhada na solução nutritiva. Isto foi necessário para que o ar saísse na solução nutritiva com a mesma temperatura desta.

Quando não se fez isto, as plantinhas que se achavam próximas do local de borbulhamento de ar, nos tratamentos com temperaturas mais elevadas reagiram bem melhor. É que do seu colo, no espaço existente entre la tampa do recipiente e a superficie da solução nutritiva cresceram raízes normais por estarem recebendo corrente de ar na temperatura ambiente.

O experimento foi instalado dentro de uma pequena estufa, especialmente construida. A temperatura no interior da estufa era controlada por uma unidade de refrigeração regulada de maneira a impedir que durante o dia a temperatura ambiente ultrapassasse 27ºC.

Após seis meses o experimento foi encerrado, as plantas medidas e pesadas. O teor de macronutrientes foi determinado na parte aérea e nas raizes, separadamente.

Resultados e discussão

Crescimento

A Figura 1 mostra as plantinhas no término do experimento. No Quadro 1 encontram-se os dados relativos a altura e peso das plantas.

Vê-se que entre 29ºC e 33ºC o acréscimo de um grau apenas de temperatura, nas raízes, causou pronunciado decréscimo no crescimento do cafeeiro. As temperaturas mais elevadas prejudicaram mais as raízes do que a parte aérea, o que se torna evidente pelas maiores relaçoes parte aérea/raiz. Os resultados encontrados com macieira por Gur *et al* (2) se assemelham bastante a estes.

Absorção de nutrientes

Nitrogênio: Houve um pequeno decréscimo no teor de nitrogênio das partes aéreas e das raízes a medida que a temperatura se elevou acima de 29ºC (Figura 2). Esse decréscimo foi um pouco mais acentuado nas raízes do que nas partes aéreas.

Fósforo: É interessante notar que o teor de fósforo na parte aérea decresceu acentuadamente com a elevação da temperatura da solução nutritiva de 30ºC para 33ºC enquanto o seu teor nas raízes aumentou (Figura 3). Parece pois que não é a absorção do fósforo que é prejudicada pela elevação da temperatura mas sim a sua translocação das raizes para as partes aéreas.

Magalhães (4) trabalhando com cafeeiros de três meses de idade, transplantados do solo para solução nutritiva com fósforo radioativo, observou que as plantas submetidas diariamente a temperatura de 45ºC nas raizes, durante cerca de duas horas, mostraram um insignificante acúmulo de fósforo na parte aérea após cinco e quinze dias de tratamento. Não foi determinado o fósforo nas raízes. Nas plantas submetidas ao mesmo tratamento durante trinta dias não foi encontrado fósforo nem nas partes aéreas. Entretanto, a temperatura de 45ºC empregada por aquele autor está bem acima do limite letal para as raizes do cafeeiro, o qual achase entre 33ºC e 38ºC Franco (1) tendo mesmo resultado na morte das plantas.

Potássio: A maior reação à temperatura elevada nas raízes foi observada no caso do potássio (Figura

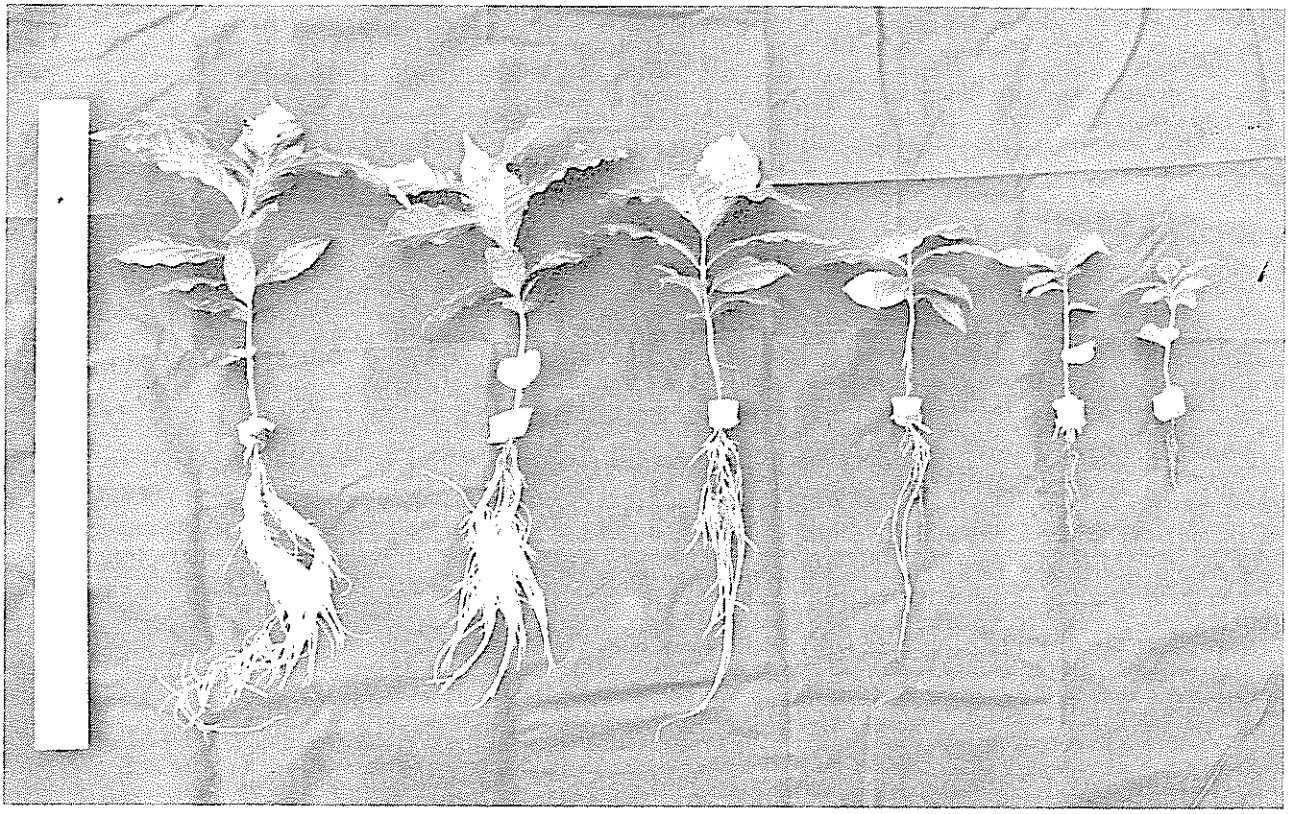

Fig. 1. Cafeeiros cultivados em solução nutritiva com temperatura controlada. Da esquerda para a direita: 27º, 29º, 30º, 31º, 32º e 33º centígrados

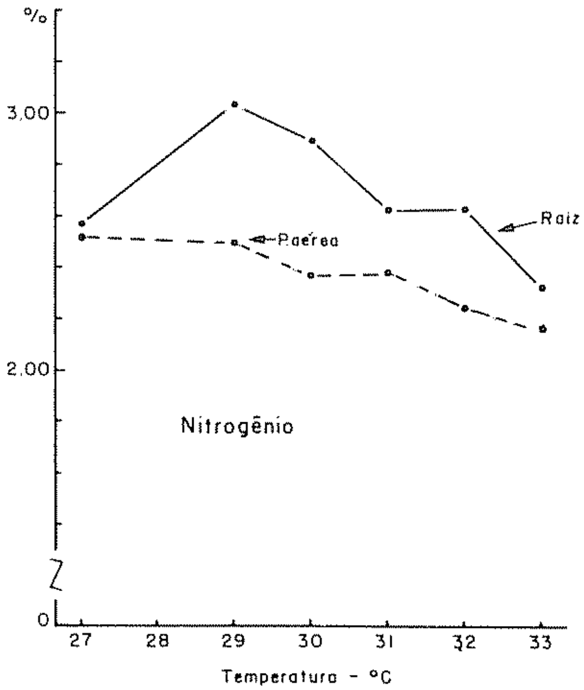

Fig. 2. Teor de nitrogênio nas partes aéreas e nas raízes dos cafeeiros cultivados em solução nutritiva com temperatura controlada.

3). O teor deste elemento tanto nas raízes quanto nas partes aéreas aumentou enormemente com elevação da temperatura da solução nutritiva de 27ºC para 31ºC.

Cálcio: Quanto ao cálcio (Figura 4) houve um decréscimo no teor entre 29ºC e 31ºC, muito mais acentuado nas raízes do que na parte aérea e depois um acentuado aumento até a temperatura de 33ºC.

Magnésio: No caso do magnésio (Figura 4) enquanto na parte aérea houve tendência para decrescer acima de 30º no sistema radicular deu-se o inverso. Parece pois que, como no caso do fósforo, não é a absorção do magnésio que é prejudicada pela temperatura elevada mas sim, a sua translocação das raízes para as partes aéreas.

Resumo

Cultivou-se cafeeiros recém-germinados em solução nutritiva cuja temperatura foi mantida constante em diferentes recipientes nos valores de: 27, 29, 30, 31, 32 a 33 graus centígrados.

Quadro 3. Altura e peso das plantas submetidas a diferentes temperaturas no sistema radicular.

Temperatura da solução nutritiva	Altura média	Peso fresco da parte aérea (média)	Peso fresco das raízes (média)	Relação parte aérea/raíz
°C	cm	g	g	
27	29.4	10.1	6.4	1.58
29	24.5	8.3	6.1	1,36
30	19.3	5.4	2.5	2.16
31	16.3	4.0	1.7	2.35
32	13.9	2.6	0.8	3.25
33	13.1	1.6	0.5	3.20

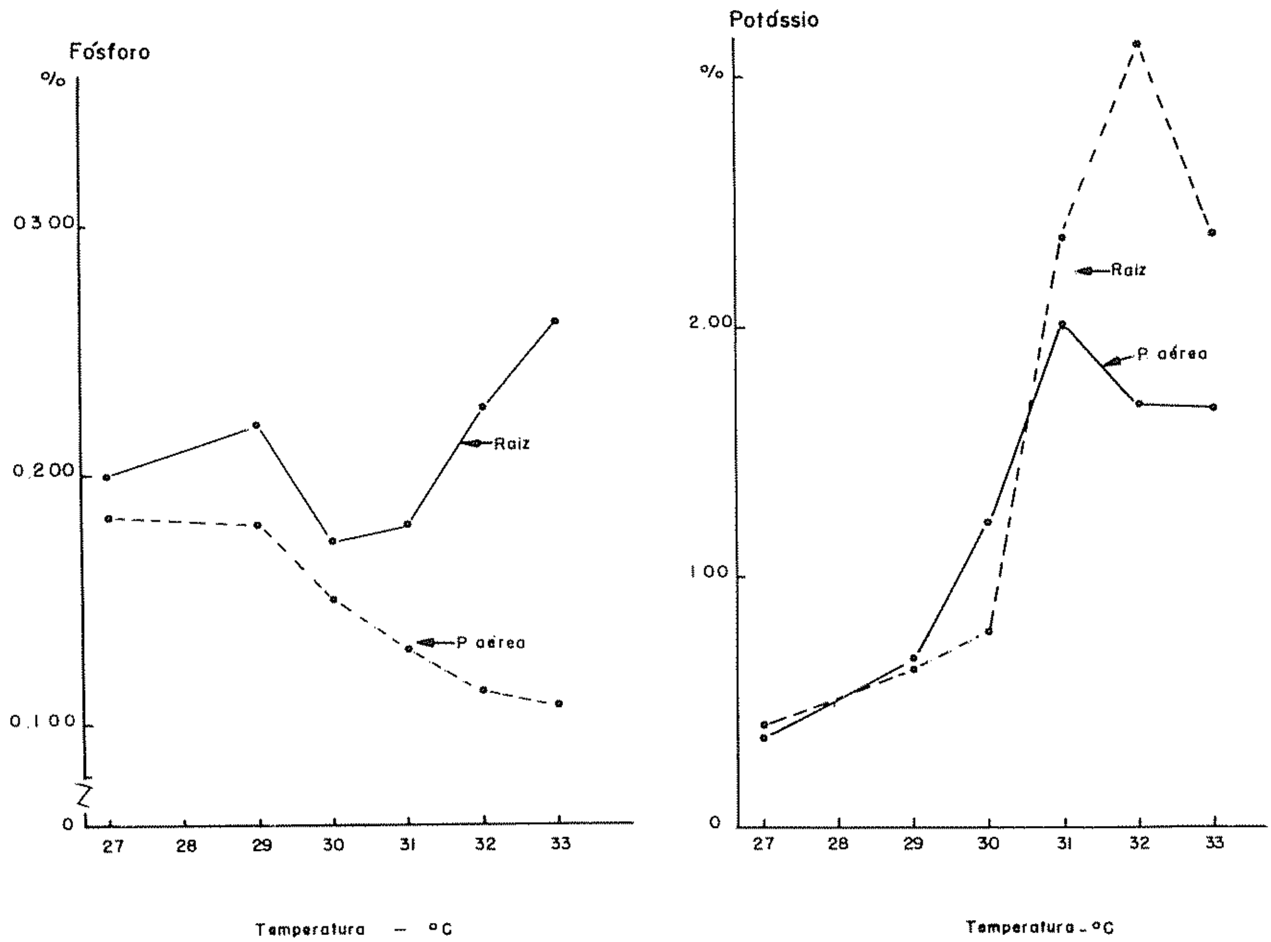

Fig. 3 Teores de fósforo e de potássio nas partes aéreas e nas raizes dos cafeeiros cultivados em solução nutritiva com temperatura controlada.

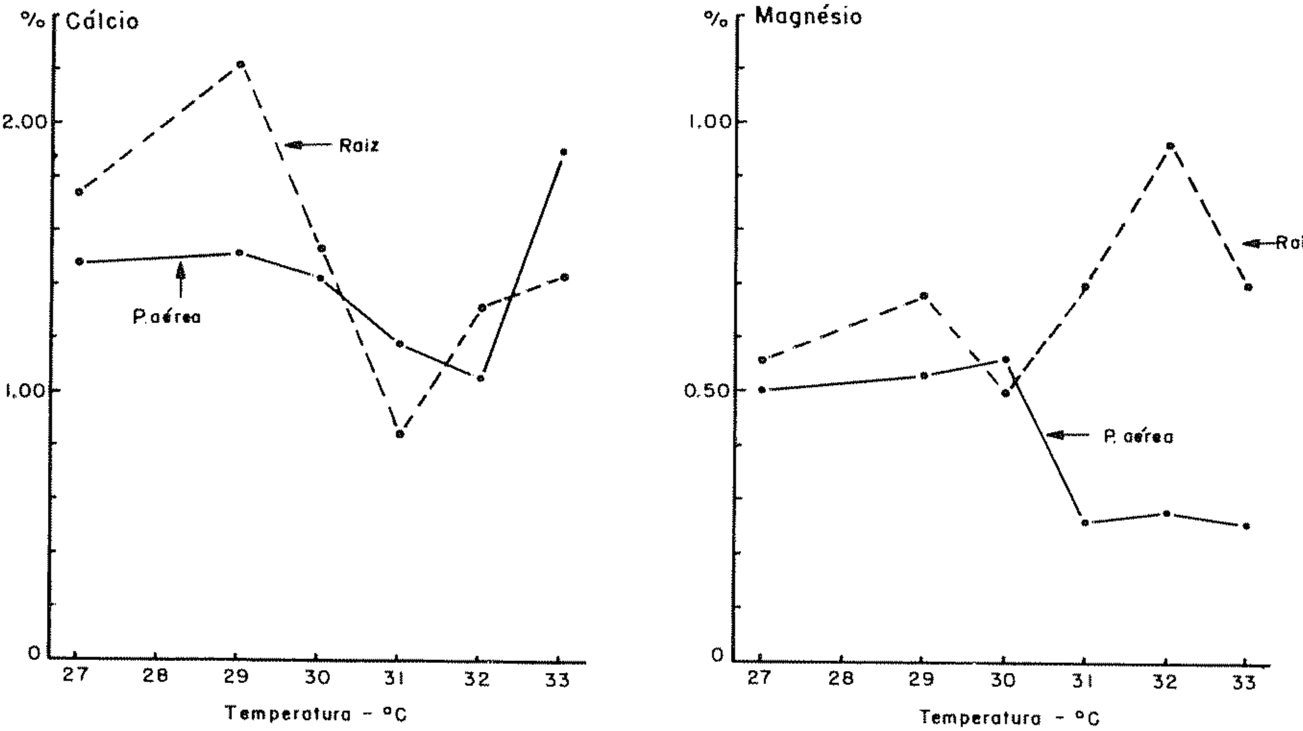

Fig. 4. Teores de cálcio e de magnésio nas partes aéreas e nas raízes dos cafeeiros cultivados em solução nutritiva com temperatura controlada.

Aos seis meses de idade as plantinhas foram medidas e suas raízes e partes aéreas pesadas separadamente e analizadas quanto aos seus teores de N, P, K, Ca e Mg.

Observou-se que entre 29°C e 33°C o acréscimo de um grau na temperatura do sistema radicular resultou em um pronunciado decréscimo no crescimento das plantas.

Quanto aos teores de nutrientes, o que de mais interessante se observou foi que nas temperaturas mais elevadas os teores de fósforo e de magnésio aumentaram acentuadamente nas raízes e diminuiram nas partes aéreas sugerindo que a translocação desses elementos para as partes aéreas foi grandemente prejudicada pelas temperaturas mais elevadas nas raízes.

Houve também pronunciado acúmulo de potássio nas temperaturas mais elevadas, tanto nas raízes quanto nas partes aéreas.

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Reseña de libros

MALAGON, D. Fundamentos de mineralogía de suelos, 2 tomos, Centro Interamericano de Desarrollo Integral de Aguas y Tierras. Mérida, Venezuela. 1979. 747 p.

Este trabajo es el primer libro latinoamericano sobre mineralogía de suelos. Su orientación va hacia el estudiante y por lo tanto incluye el material complementario necesario para la comprensión de sus puntos principales.

Es también de las pocas mineralogías de suelos verdaderas, ya que considera tanto los minerales de arcilla, como ocurre en muchos otros textos, así como la minerología de los componentes de las fracciones arena y limo.

Hay que anotar que la edición merecía más cuidado ya que contiene serios errores, por ejemplo no incluir en el índice la bibliografía del primer capítulo. Hay referencias citadas dos veces y otras de un trabajo editorial deficiente.

En lo que refiere a la bibliografía ésta se orienta hacia el estudiante y no hacia el especialista; se cita mucho texto y referencias clásicas pero no aparece la bibliografía reciente. Se puede afirmar que los descubrimientos de la última década casi no son considerados en la obra. Otra mejora apreciable que se podría hacer para un volumen que no es únicamente para el uso colombiano, es considerar la apreciable bibliografía latinoamericana de otros países, además de aquella relacionada con Colombia.

El trabajo se subdivide en siete capítulos, tres de los cuales forman el primer volumen de 484 páginas.

El primer capítulo, titulado Geopedología, de casi 90 páginas, se dedica a una introducción general sobre la formación y evolución de la tierra, principios de cristolografía y petrografía y los minerales silicatados. No menos de 28 figuras ayudan al lector a familiarizarse con los conceptos del capítulo.

El intemperismo es el tema del segundo capítulo de más de 150 páginas. Aunque esta materia no está muy estrechamente relacionada a la mineralogía de suelos, contribuye a su comprensión y proporciona una visión global sobre los componentes inorgánicos de los suelos. Se discute en el capítulo el intemperismo químico y físico y la respuesta de los principales elementos al proceso; se estudia ampliamente los minerales en el proceso del intemperismo y las rocas brevemente. Una bibliografía de 101 referencias concluye el capítulo.

En el capítulo tres se estudia los minerales arcillosos. En esta división del libro, de más de 250 páginas, se discute el origen, clasificación, propiedades e identificación de las arcillas, con una sección especial dedicada a arcillas de Colombia. Es una lástima que al campo tan activo de la interacción arcillas con materiales orgánicos se dedique solamente, 4 páginas sin referencia de la última década. La información sobre la metodología de análisis instrumental es muy completa y ofrece una amplia introducción a estas técnicas.

El capítulo cuarto, con el cual comienza el segundo volumen, ofrece una discusión de la mineralogía de arena y del limo grueso. Este es un tema sobre el cual no hay mucha información en textos, y menos en castellano, por lo cual este es material muy útil para el lector de habla hispana. De nuevo hay una amplia descripción de los métodos empleados en este campo, de gran utilidad para los estudiantes.

La formación del suelo y sus implicaciones mineralógicas son la materia del capítulo quinto, compuesto de no menos de 150 páginas. En la primera parte se discute la formación de suelos en general; le sigue una discusión de la micromorfología del suelo y el capítulo concluye con la discusión de la relación de la mineralogía del suelo con su génesis y taxonomía.

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EFEITO DA TEMPERATURA DO SOLO E SUAS OSCILAÇÕES SOBRE O CRESCIMENTO E O ACÚMULO DE NUTRIENTES NAS PARTES AÉREAS DO CAFEEIRO[1] */

COARACY M. FRANCO**

Summary

An apparatus was developed to control soil temperature inside experimental pots. The temperature was controlled in such a way as to imitate closely the continuous variation of the temperature of the top layers of the soil in the field during the daily 24 hour period.

Starting from a predetermined lower level in the morning, the temperature was increased slowly to a maximum predetermined level just after noon. After staying about two hours at this higher level the temperature decreased slowly until reaching again the morning temperature. This daily cycle was maintained during the experiment. The lower and higher temperatures and the rate of their increase and decrease can be adjusted within wide limits. This equipment was used to study the influence of the soil temperature and its oscillation on the coffee plant growth.

The temperature of 33°C in the root system, for a period of about two hours daily, resulted in a small decrease in the weight of the aerial parts and a pronounced decrease in the weight of the root system, but did not result in a noticeable decrease in the height of the plants in relation to those kept at a constant 23°C. Under similar conditions the maximum temperature of 38°C for a period of about two hours caused a pronounced decrease in the height of the plants and in their top and root weight.

At the constant temperature of 33°C in the root system the height of the plants and the weight of their tops and roots were drastically reduced. There is evidence showing that the reduction of the growth of the coffee plants at the higher temperatures tested is due to a lack of translocation of the absorbed phosphorus from the roots to the aerial parts.

Introdução

Em solos mantidos limpos e portanto sujeitos a incidência direta dos raios solares, a temperatura das camadas superficiais, justamente aquelas em que há maior concentração de radicelas, atinge em dias ensolarados, níveis incompatíveis com as funções das raizes ou mesmo com a vida dos seus tecidos.

Em culturas novas de cafeeiros, enquanto as plantas, ainda pequenas não sombreiam o solo, as camadas superficiais do solo se aquecem demasiadamente. Nestas condições Medcalf (5) observou que no verão, a temperatura do solo a cinco centímetros de profun-

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* Trabalho executado no Instituto Agronômico de Campinas em convênio com o Instituto Brasileiro do Café. Expressamos os nossos agradecimentos à Fundação Rockefeler pela doação de parte do equipamento usado, aos técnicos da Seção de Química Analítica do Instituto Agronômico de Campinas pelas dosagens dos nutrientes nas plantas. Agradecemos também aos auxiliares Arlindo Salles Nogueira e Avelino Marion *post mortem* pela dedicação e eficiência que demonstraram durante a execução do experimento e na manutenção do equipamento

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didade atingiu até 51°C, no solo Podzolizado de Lins e Marília, Variação Marília (Alfisol, grupo dos Tropudalf). No Latossolo Roxo (Eutrortox), Lopes da Costa e Godoy (4) encontraram que a 10 cm de profundidade a temperatura do solo permaneceu acima de 30°C durante oito horas e trinta minutos (das 11:00 às 19:30) e acima de 33°C durante seis horas (das 12:00 às 18:00). Como se verá neste trabalho, essas temperaturas já são bastante prejudiciais ao cafeeiro.

Franco (2) demonstrou que o cafeeiro se desenvolve melhor quando suas raizes estão sujeitas à temperatura de 23°C a 28°C. A 33°C o desenvolvimento foi mínimo. Deve-se notar que no trabalho citado a temperatura do sistema radicular foi mantida constante. Entretanto, no campo, nas condições de cultura, a temperatura do solo nos primeiros decímetros de profundidade, onde em geral está a maior concentração de raízes não é constante, mas oscila entre um mínimo ao nascer do sol e um máximo logo após o meio dia.

Para estudar o efeito dessas oscilações de temperature sobre o cafeeiro, quando suas raízes ficam sujeitas à temperaturas desfavoráveis por algumas horas, desenvolveu-se um equipamento especial que uma vez regulado reproduzia no interior dos vasos onde cresciam os cafeeiros, oscilações diárias de temperatura semelhantes àquellas que ocorrem nas condições de cultura.

Material e método

A Figura 1 representa, em corte, uma das quatro unidades controladoras da temperatura dos vasos empregadas no experimento. Cada unidade foi regulada para temperaturas com as oscilações térmicas desejadas. O refrigerador era comum, servindo às quatro unidades.

Na parte superior da estrutura de madeira achavam-se quatro vasos de barro com capacidade para 6 litros de terra cada um e isolados externamente por placas de isopor. Antes dos vasos serem cheios com terra foi instalada no interior de cada um deles uma serpentina de cobre banhada com estanho. Essas serpentinas estavam ligadas em série e por elas a água do tanque, com temperatura controlada, circulava ininterruptamente, acionada pela bomba 1 (Figura 1).

Em cada vaso foi transplantada uma plantinha de café do cultivar Catuaí Vermelho com apenas um par de folhas em desenvolvimento.

A temperatura da água era controlada por dois termostatos; um regulado para manter a temperatura mínima noturna e outro para controlar a temperatura máxima diurna. Um interruptor horário estava regulado para, de manhã, passar o controle da temperatura da água do tanque para o termostato que controlava a temperatura máxima diurna. Assim, a temperatura da água circulante se elevava e permanecia constante quando atingia o valor para o qual o termostato estava regulado. A tarde, na hora previamente determinada, o interruptor horário transferia o controle da temperatura da água para o termostato regulado para a temperatura mínima noturna que era atingida pela madrugada e permanecia até a manhã seguinte quando o interruptor horário transferia novamente o controle da temperatura para o termostato regulado para a temperatura máxima diurna.

A razão desejada de elevação da temperatura era conseguida por meio do reostato ligado em série com a resistência aquecedora. A razão de decréscimo da temperatura conseguia-se regulando a temperatura da água do refrigerador e a vasão da sua circulação na serpentina de água fria, através de um registro instalado no retorno da água ao refrigerador, depois da bomba 2 (Figura 1) que forçava a circulação da água fria. Um interruptor horário ligava essa bomba às 9 horas e a desligava às 17 horas já que fora desse horário a temperatura ambiente era suficientemente baixa para fazer cair lentamente a temperatura da agua circulante nos vasos até alcançar o controle do termostato de temperatura mínima.

Os tubos de circulação de água refrigerada eram isolados externamente com isopor a fim de reduzir ao mínimo o efeito da temperatura ambiente. O esquema elétrico das unidades está representado na Figura 2.

Com as possibilidades de regulagem descritas, conseguiu-se simular dentro dos vasos, as oscilações de temperatura que ocorrem no campo, em condições naturais, isto é, a partir de um mínimo pela madrugada a temperatura subia gradativamente até um máximo após o meio dia, permanecia nesse máximo por cerca de duas horas e descia lentamente até um mínimo pela madrugada e assim sucessivamente em cada vinte e quatro horas.

Para o presente trabalho as unidades de controle da temperatura foram reguladas para as seguintes temperaturas na terra dos vasos:

1. (23° – 23°) temperatura constante de 23°C dia e noite;

2. (33°–33°) temperatura constante de 33°C dia e noite;

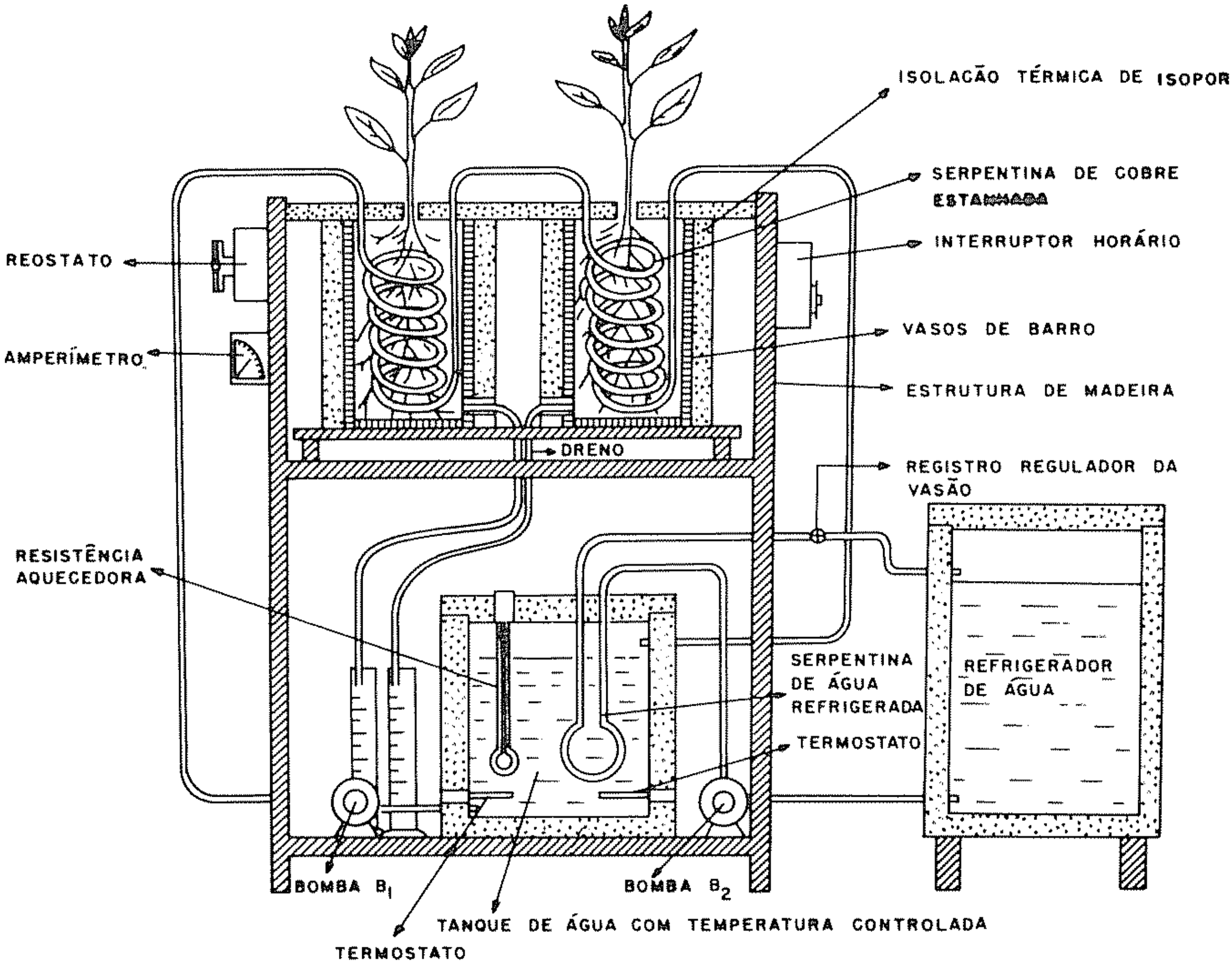

Fig. 1. Equipamento para controle da temperatura do solo no interior dos vasos. Na figura, em corte, estão representados apenas dois dos quatros vasos existentes.

3. (23°–33°) temperatura de 23°C pela manhã, subindo lentamente até 33°C logo após o meio dia, permanecendo nessa temperatura por cerca de duas horas e decrescendo em seguida, lentamente, até 23°C pela madrugada;

4. (23°–38°) temperatura de 23°C pela manhã, subindo lentamente até 38°C logo após o meio dia, permanecendo nessa temperatura por cerca de 2 horas e decrescendo em seguida, lentamente, até 23°C pela madrugada.

A Figura 3 mostra as oscilações de temperatura nos tratamentos com temperatura oscilante (tratamentos 3 e 4).

Resultados e discussão

Altura das plantas

Nos primeiros dois meses de tratamento não houve diferença no crescimento em altura das plantas submetidas aos quatro diferentes tratamentos térmicos (Figura 4). A partir daí e principalmente depois do terceiro mês é que se manifestaram diferenças no crescimento daquelas plantas.

As plantas dos tratamentos 23°C – 23°C e 23°C – 33°C exibiram praticamente o mesmo crescimento em altura, indicando que temperaturas de até 33°C

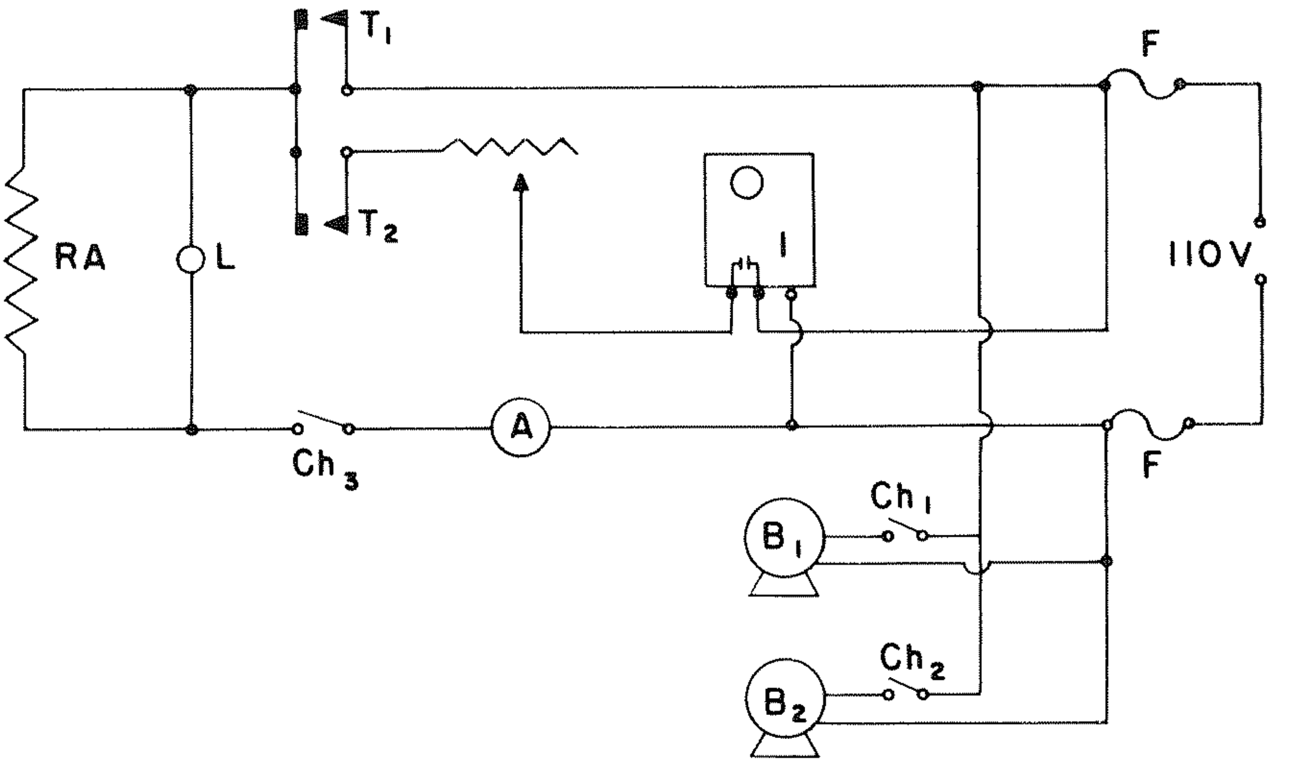

Fig. 2. Esquema elétrico das unidades de controle da temperatura do solo no interior dos vasos.

F: fusiveis. I: interruptor horário. B_1: bomba para circulação de água a temperatura controlada nas serpentinas dos vasos. B_2: bomba para circulação de água refrigerada na serpentina do interior do tanque de controle da temperatura da água circulante. Ch. 1 = chave para desligar a bomba B_1. Ch.$_2$ = chave para desligar a bomba B_2. R = reostato para regulagem do aquecimento de água. T_1 = termostato para controle da temperatura mínima dos vasos. T_2 termostato para controle da temperatura máxima dos vasos. A: amperímetro. Ch. 3 = chave para desligar a resistência aquecedora. L = lâmpara piloto da resistência aquecedora. RA = resistência aquecedora.

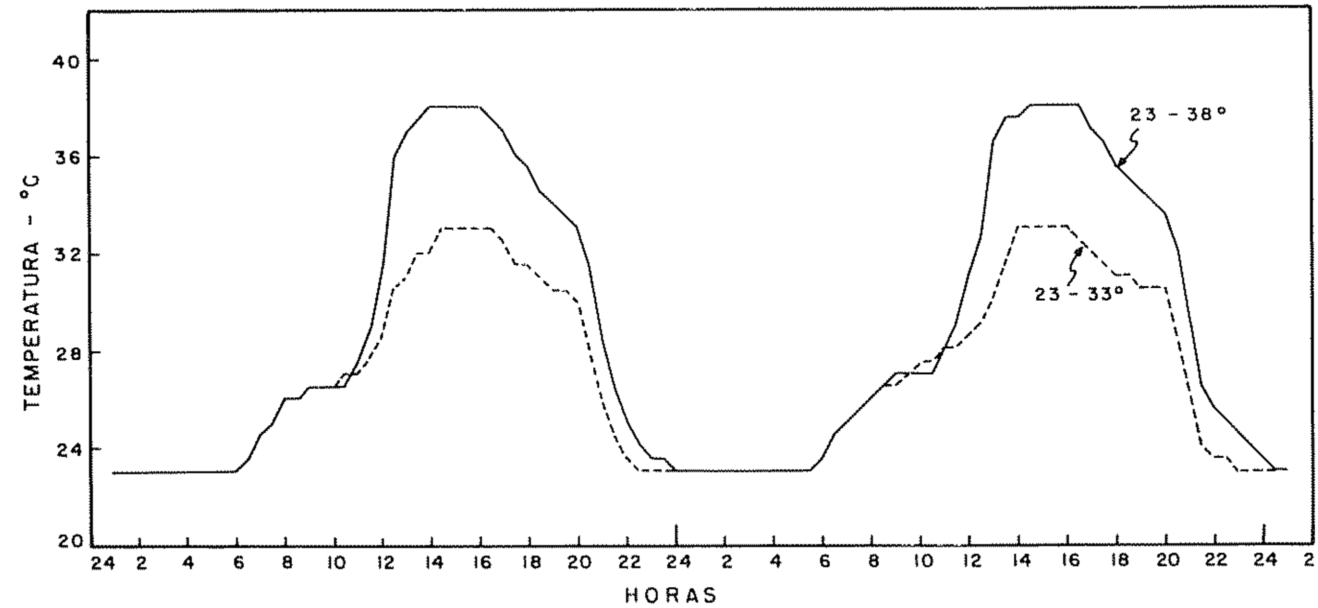

Fig. 3. Oscilações diárias da temperatura no solo dos vasos submetidos às temperaturas de 23º à 33ºC e de 23º à 38ºC.

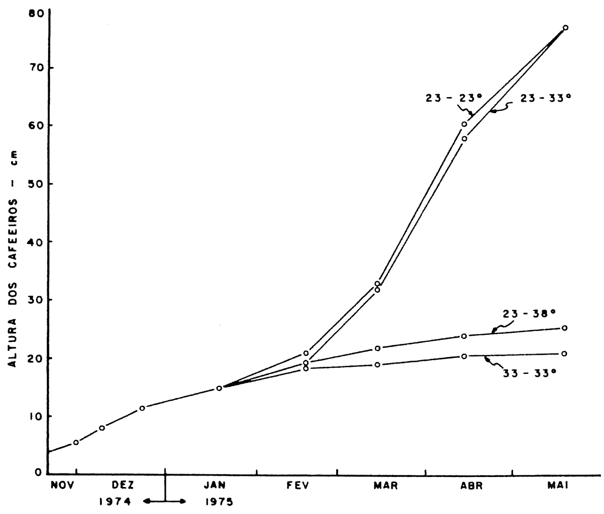

Fig. 4. Crescimento em altura, dos cafeeiros submetidos aos diferentes tratamentos térmicos nas raízes.

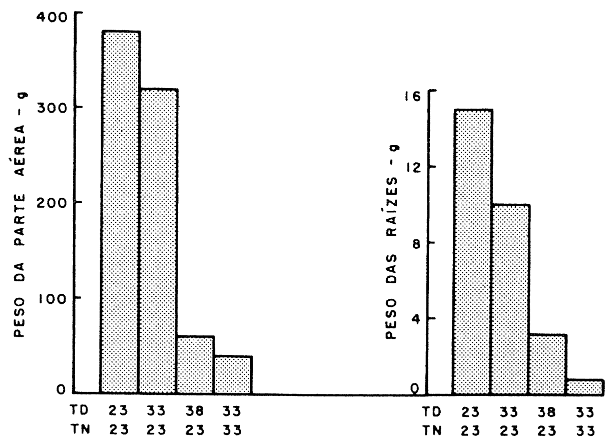

Fig. 5. Pêso dos cafeeiros submetidos aos vários tratamentos térmicos nas raízes. TD = temperatura máxima diurna. TN = temperatura mínima noturna.

no solo por um período de duas horas não prejudicam apreciavelmente o crescimento do cafeeiro.

As plantas dos tratamentos 33°C – 33°C e 23 – 38°C apresentaram crescimento mínimo nos últimos três meses do experimento mostrando que a temperatura constante de 33°C e a oscilante com um máximo de 38°C por duas horas diariamente prejudicaram enormemente o crescimento do cafeeiro, mas somente nos últimos três meses do experimento.

O fato de as plantas terem apresentado crescimento igual nos primeiros meses e somente após esse período exibirem diferença poderia ser explicado pelo fato da translocação do fósforo das raízes para as partes aéreas ser inibida por temperaturas supraótimas Franco (3). Provavelmente o fósforo já contido viveiro para os vasos experimentais foi suficiente para o período inicial de crescimento das plantas submetidas às temperaturas supraótimas.

Peso das partes aéreas

O peso fresco das plantas dos diferentes tratamentos variou de maneira semelhante às alturas (Figura 5). Com o peso, porém, observa-se que as temperaturas elevadas, de até 33°C, mesmo por poucas horas, prejudicaram sensivelmente as plantas, pois pesaram 16% menos que aquelas que cresceram na temperatura ótima, de 23°C constante.

Como no caso da altura, o peso dos cafeeiros foi grandemente prejudicado pela temperatura constante de 33°C e também pela temperatura oscilante com o máximo de 38°C, embora permanecendo nessas temperaturas por cerca de duas horas em cada dia.

Peso das raízes

Observa-se na Figura 5 que o efeito dos tratamentos térmicos sobre o peso das raízes foi semelhante ao efeito sobre o peso da parte aérea.

De um modo geral, as temperaturas supraótimas prejudicaram mais as raízes do que a parte aérea. Esta observação concorda com trabalho anterior (Franco 3), e com os resultados de Barr e Pellet (1) com várias espécies lenhosas.

Absorção de nutrientes

A Figura 6 mostra o teor de macronutrientes encontrados nas folhas dos cafeeiros correspondentes aos diferentes tratamentos térmicos do solo. Não foi possível dosar os elementos minerais nas raízes devido ao seu pequeno peso seco à grande contaminação com a terra dos vasos, impossível de ser totalmente eliminada.

Não seria recomendável estabelecer muitas comparações entre os resultados obtidos neste experimento com aqueles obtidos em trabalhos anteriores Franco (2), uma vez que os tratamentos térmicos não foram idênticos e o ambiente radicular foi diferente. No primeiro trabalho empregou-se temperaturas constantes e substrato inerte e poroso regado diariamente com solução nutritiva. No segundo, as plantas foram cultivadas com as raízes mergulhadas em solução nutritiva à temperatura constante. No

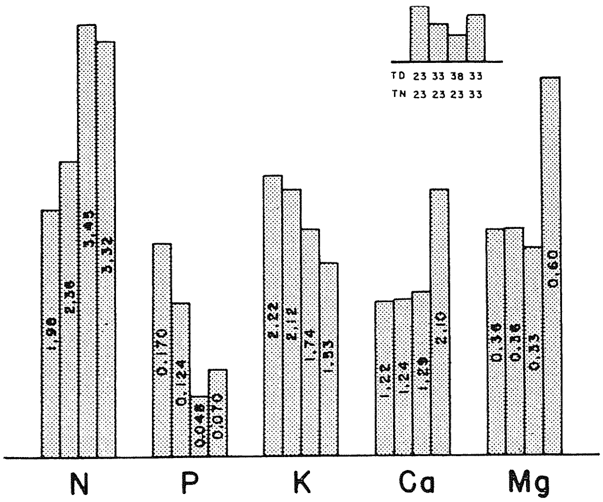

Fig. 6. Teor de elementos nutritivos nas folhas dos cafeeiros submetidos aos vários tratamentos térmicos nas raízes.

presente experimento as plantas vegetaram em vasos com terra e temperatura oscilante.

Entretanto, dada a consistência dos resultados referentes ao fósforo, obtidos nos três experimentos é interessante frizar que, como nos experimentos anteriores, o teor de fósforo nas folhas decresceu acentuadamente com a elevação da temperatura no ambiente das raízes. Esse fato foi anteriormente observado em outras espécies lenhosas por Barr e Pellet (1).

Vê-se ainda na Figura 6 que no experimento em discussão, em vasos com terra, o teor de nitrogênio das folhas aumentou com a elevação da temperatura nas raízes.

Houve decréscimo do teor de potássio nas plantas submetidas a temperaturas mais elevadas. Quanto ao cálcio e ao magnésio seus teores aumentaram acentuadamente no tratamento térmico de 33°C – 33°C enquanto nas outras temperaturas houve apenas pequenas variações.

Conclusões

Quando a temperatura no sistema radicular do cafeeiro elevou-se gradativamente da temperatura ótima de 23°C pela manhã até 33°C, logo após o meio dia, permanecendo nesta por cerca de duas horas e decrescendo lentamente para 23°C à noite, não houve prejuízo no crescimento do cafeeiro em altura. Houve, porém, um pequeno decréscimo no peso da parte aérea e um decréscimo mais acentuado no peso das raízes.

Nas mesmas condições, quando a temperatura do solo se elevou até o máximo de 38°C, houve acentuado decréscimo na altura das plantas, no peso fresco das partes aéreas e no peso fresco das raízes.

Quando os cafeeiros vegetaram em solo com temperatura constante de 33°C, o crescimento em altura, o peso da parte aérea e o das raízes foram mínimos.

A temperatura oscilante de 23°C a 38°C e a temperatura constante de 33°C só prejudicaram o crescimento das plantas em altura após os três primeiros meses de tratamento.

Nos tratamentos de 23°C–33°C; 23°C–38°C e 33°C–33°C; principalmente nos dois últimos o teor de fósforo nas folhas foi grandemente reduzido.

Conforme conclusão em trabalho anterior Franco (3) não é a absorção de fósforo pelas raízes que é prejudicada pelas temperaturas supraótimas mas sim a sua translocação das raízes para as partes aéreas.

Resumo

Desenvolveu-se um equipamento para controlar a temperatura de solo no interior de vasos experimentais de maneira a simular as variações normais de temperatura que ocorrem nas camadas mais superficiais do solo, durante as 24 horas do dia.

Subindo lentamente de um mínimo pela manhã, a temperatura atingia um máximo logo após o meio dia, permanecia nesse máximo por cerca de duas horas e decrescia, em seguida lentamente, até atingir de novo a temperatura mínima, pela madrugada. O tempo em que o solo no interior do vaso fica sujeito às temperaturas máxima e mínima pré-determinadas e a razao da elevação e do decréscimo da temperatura entre aqueles limites podem ser reguladas dentro de amplos limites.

Utilizando-se esse equipamento estudou-se a influência da temperatura do solo e suas variações diárias, sobre o crescimento do cafeeiro. A temperatura máxima de 33°C durante um período de cerca de duas horas diariamente provocou uma pequena redução no peso das partes aéreas e um decréscimo mais acentuado no peso das raízes em relação a temperatura ótima de 23°C sem contudo afetar visivelmente a altura dos cafeeiros. Nas mesmas condições, a temperatura máxima de 38°C durante cerca de duas horas diariamente resultou em um decréscimo acentuado na altura das plantas e nos pesos das partes aéreas e das raízes.

A temperatura constante de 33°C, restringiu enormemente o crescimento em altura e o peso da parte aérea e das raízes.

Conforme trabalho anterior Franco (3) o prejuízo causado ao desenvolvimento dos cafeeiros pelas temperaturas mais elevadas parece ser conseqüência da inibição da translocação de fósforo, das raízes para as partes aéreas naquelas temperaturas, ficando aquele elemento acumulado nas raízes.

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REPARACION DE MOTORES DE TRACTORES AGRICOLAS
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METODOS DE INVESTIGACION FITOPATOLOGICA

MORFOLOGIA Y BIOLOGIA DE LOS CRISOMELIDOS *Diabrotica balteata* LeConte Y *Cerotoma facialis* ERICKSON COMO PLAGAS DEL FRIJOL COMUN[1] /

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Summary

The morphology, biology and habits of the chrysomelids Diabrotica balteata *LeConte and* Cerotoma facialis *Erickson as pests of common beans are described following laboratory (27°C; 80% R.H.) and greenhouse studies. It was found that larvae of* D. balteata *do not survive when feeding on bean roots, and* C. facialis *will not attack maize seedlings. Eggs of* D. balteata *and* C. facialis *lasted an average of 5.1 and 6.4 days, respectively. Both species have three larval instars which are passed in 14 days in the case of* D. balteata *and 10.6 days for* C. facialis. *Pupae form in a cell in the ground and this stage lasts from 6 to 7 days. In both species the sex ratio was 1:1. When fed bean foliage, females lived an average of 37 days (*Diabrotica*) and 52 days (*Cerotoma*). In both species the preoviposition period varied from 5 to 12 days.*

The maximum egg production by adult D. balteata *that fed on bean leaves was 144 per female;* C. facialis *females laid up to 532 eggs. Both species consume more foliage during the first two weeks of their lifespan.*

Introducción

En América Latina el frijol es atacado por un complejo de crosomélidos que abarca unas 36 especies (Ruppel e Idrobo, 15). De este complejo, varias especies de los géneros *Diabrotica* y *Cerotoma* revisten la mayor importancia económica, tanto por el daño mecánico que causan como consumidores de follaje, raíces, flores y vainas tiernas (CIAT, 5), así como también por ser vectores de virus tales como los del mosaico rugoso y del moteado de la vaina (Gámez, 6), enfermedades que son igualmente de importancia económica.

Nichols *et al.* (11) registran al *Cerotoma facialis* Erickson como una especie plaga en Panamá, Perú y Colombia. *Diabrotica balteata* LeConte tiene una distribución más amplia (Pulido y López, 13), ya que se ha encontrado en áreas de altitudes menores a 2 000 metros en Estados Unidos, México, Honduras, Guatemala, Nicaragua, Costa Rica, Colombia, Venezuela y Perú.

Se conoce poco sobre los hospedantes de *C. facialis*. Ocurre como plaga en frijol y soya, demostrándose que es una especie mejor adaptada al frijol que *D. balteata* (Boonekamp, 1; Hernández, 9), el cual presenta un amplio rango de plantas hospedantes, aunque los adultos prefieren alimentarse del follaje de frijol (Schoonhoven y Cardona, 16). Pulido y López (13) relacionan 32 especies de plantas atacadas por *D. balteata*, de las cuales maíz y frijol se consideran hospedantes de adultos y estados inmaduros. Chiang (4) menciona que las larvas de *D. balteata* causan un gran daño en raíces de maíz, en donde se

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alimenta de los pelos radiculares y del corazón de la raíz aunque el consumo se reduce ampliamente cuando la corteza blanda de ésta crece y se lignifica.

Los estudios sobre el ciclo biológico de *D. balteata* difieren en el número de instares larvales según el autor. Young y Candia (17) y Gent (7) mencionan cuatro instares con una duración de 24 a 28 días mientras que Pulido y López (13) encontraron tres. En ambos estudios el ancho de la cápsula céfalica fue similar.

La biología de *C. facialis* fue estudiada por González y Cardona (8) y en ella se reportan tres instares larvales. Para efectos del presente trabajo se tomó este estudio, se completó y se comparó con los datos obtenidos, a las mismas condiciones ambientales, para *D. balteata*.

La importancia de las diferentes especies de crisomélidos varía según la región y el país pero hay indicios de que *D. balteata* y *C. facialis* son las dos más importantes en frijol en América Latina. Por tal razón, el objeto fundamental de este estudio fue conocer la morfología, el ciclo biológico y los aspectos más importantes de la historia natural de estas dos especies como plagas del frijol común, *Phaseolus vulgaris* L.

Materiales y métodos

Los trabajos se realizaron en la Estación Experimental del Centro Internacional de Agricultura Tropical (CIAT), localizado en Palmira, Valle del Cauca, Colombia. En la mayoría de los casos las condiciones ambientales promedio fueron de 27°C y 80% de humedad relativa.

Para la cría y mantenimiento de los crisomélidos en estudio se hicieron algunas modificaciones a las metodologías generales discutidas por Pitre y Kantack (12), Chalfant y Mitchel (3), Raros y Holdaway (14) y Branson *et al.* (2).

Mediante el uso de una aspiradora de motor tipo D-Vac, se capturaron adultos de crisomélidos en cultivos de frijol y/o soya en floración, se llevaron al laboratorio y se colocaron en jaulas de 0.8 x 0.8 x 0.8 m. Con un aspirador de boca se separaron hembras de *D. balteata*, con base en la forma del último segmento abdominal (Branson *et al.*, 2) y de *C. facialis* por la forma de sus antenas (González y Cardona, 8).

Las hembras seleccionadas se colocaron en número de diez por cámara de oviposición (caja de Petri de 14 cm de diámetro y 2.5 cm de altura, provistas de un orificio circular cubierto con tela delgada para facilitar la aireación). En el fondo de cada cámara se depositó una capa de gasa humedecida y sobre ésta, hojas, flores y vainas tiernas de frijol. A los dos días se revisaron las cajas y se retiraron de ellas los huevos depositados, los cuales fueron tratados en algunos casos con sulfato cúprico al 1% durante 5 minutos para evitar su contaminación; luego fueron transferidos separadamente a 10 cajas de Petri (100 por caja) provistas de papel filtro húmedo en el fondo y colocadas en una cámara ambiental a 27°C y 80% de humedad relativa y un fotoperíodo aproximado de 20 horas, donde se revisaron diariamente hasta su eclosión. Con las larvas que se obtuvieron de cada especie se hicieron dos tipos de experimentos: en primer lugar se estableció el hábito y aceptación alimenticia en semillas de maíz y frijol germinado y en el segundo, el ciclo biológico y descripción morfológica, respectivamente.

Para los estudios de aceptación alimenticia se obtuvieron semillas de maíz y frijol de 3 y 4 días de germinadas, las cuales se infestaron en cajas de Petri con larvas recién nacidas en número de 5 por semilla. Se utilizaron 10 replicaciones. A los 4, 8 y 12 días, se observaron los hábitos alimenticios y la apariencia y supervivencia de las larvas. El alimento fue cambiado periódicamente, según el caso.

Para el seguimiento de la biología se tuvo en cuenta el hábito alimenticio de las larvas. Al inicio de la incubación de los huevos se armaron cajas de germinación con semillas de frijol y maíz tratadas con captan (50 gramos/litro de agua) para prevenir el ataque de hongos. Una vez eclosionados los huevos, se colocaron cinco larvas de *D. balteata* en cada semilla de maíz, y cinco de *C. facialis* por semilla de frijol. Se utilizaron 10 semillas de cada especie por caja de Petri. El alimento fue cambiado periódicamente para asegurar el desarrollo completo de las larvas (1 000 en total).

El ciclo biológico se siguió iniciando con base en huevos eclosionados el mismo día. El porcentaje de eclosión y la duración del tiempo de incubación se calculó con la población total de los mismos.

Para la determinación de los instares larvales se midió diariamente el ancho de la cápsula cefálica con un micrómetro ocular hasta cuando las larvas de ambas especies entraron en estado de prepupa. Con estas mediciones se aplicó la ley de Dyar.

Para facilitar la formación de las pupas las larvas que parecían entrar en estado de prepupa fueron transferidas a cajas de Petri que contenían una capa de 7 mm de espesor de arena de grano fino, ligeramente humedecida. Se hicieron observaciones diarias que permitieron conocer la duración de los estados de prepupa y pupa, el porcentaje de emergencia y la relación de sexos. Los adultos emergidos fueron trasladados a jaulas cilíndricas de malla metálica, en condiciones de invernadero (28°C; 80% H. R.) para medir su longevidad y consumo diario de área foliar de frijol. En condiciones de laboratorio se determinó el período de preoviposición y el número de huevos por hembra; todos los estados fueron medidos y descritos.

Resultados y discusión

Preferencia y hábito alimenticio de las larvas

Los resultados obtenidos en este experimento indicaron preferencias específicas hacia determinadas estructuras de la raíz o de las plántulas de maíz o frijol. Se encontró que las larvas de *D. balteata* de primer instar se alimentan de los pelos de la raíz de maíz germinado; las de segundo y tercer instar prefieren consumir las raíces primarias. En términos generales puede decirse que las larvas de esta especie mostraron menos adaptación al frijol. Así, las larvas de primer instar sólo se alimentaron de las hojas primarias y muchas perecieron atrapadas en los pelos del hipocótilo; las de segundo y tercer instar, consumieron los cotiledones aunque no afectaron el hipocótilo.

Las larvas de *C. facialis* murieron en su totalidad en un período de 4 días, cuando se colocaron en raíces de maíz germinado. En cambio, cuando fueron colocadas sobre raíces de frijol, las de primer instar barrenaron el interior de la raíz y del hipocótilo y las de segundo y tercer instar se alimentaron de las hojas primarias y de los cotiledones, destruyendo completamente la semilla.

En general, el 74% de las larvas de *D. balteata* llegó al estado prepupal en semillas de maíz germinadas y únicamente el 8% en raíces de frijol. Contrariamente, *C. facialis* no se desarrolló en maíz pero el 60% completó su ciclo en semillas de frijol (Cuadro 1).

Los anteriores resultados confirman los de otros autores (Gent, 7, Boonekamp, 1) en el sentido de que el frijol en condiciones naturales es un buen hospedante para *C. facialis* y en menor grado para *D. balteata*, especie que utiliza el maíz para el desarrollo de los estados inmaduros, aunque sus adultos consuman el follaje de frijol. Esto fue confirmado por Boonekamp (1) quien encontró que en un cultivo asociado maíz-frijol, el mayor porcentaje de las larvas encontradas en maíz dieron origen a adultos de *D. balteata*; mientras que las encontradas en frijol dieron origen a *C. facialis*.

Ciclos biológicos y descripciones morfológicas

Huevos: Los huevos de ambas especies son muy parecidos, de forma elíptica, extremo micropilar más angosto y superficie visiblemente reticulada en forma de pequeños polígonos irregulares. Sin embargo, son muy distintos en cuanto al color el cual varía en *D. balteata* desde crema hasta amarillo claro, mientras que en *C. facialis* va desde anaranjado hasta color ladrillo. Los huevos de *D. balteata* son más pequeños (0.64 y 0.39 mm) en comparación con los de *C. facialis* (0.72 y 0.42 mm de diámetro polar y ecuatorial, respectivamente). Esta diferencia en tamaño es poco apreciable al mirarlos en conjunto y por lo tanto no resulta un buen patrón de comparación.

En condiciones naturales los huevos de ambas especies son colocados alrededor de la base del tallo de las plantas, en la proximidad de las raíces, depen-

Cuadro 1. Porcentajes de supervivencia de larvas de *Cerotoma facialis* y *Diabrotica balteata* criadas en plántulas de maíz y frijol en condiciones de laboratorio (27°C; 80%H. R.).

Especie	Días después de la infestación	% supervivencia	
		en frijol	en maíz
C. facialis	4	78	0
	8	66	0
	12	60	0
D. balteata	4	22	84
	8	12	78
	12	8	74

diendo del agrietamiento del suelo. En estudios posteriores de dinámica de población en frijol se comprobó que *C. facialis* tiene mayor preferencia por ovipositar en este cultivo, lo cual está de acuerdo con los resultados de laboratorio antes descritos sobre la preferencia alimenticia de las larvas. Aparentemente, la mayor oviposición de *D. balteata* ocurre en las raíces de maiz.

En las condiciones de laboratorio inicialmente anotadas, el período de incubación de los huevos de *D. balteata* varió de 5 a 6 días para un promedio de 5.1 días, y el de *C. facialis* de 6 a 7, para un promedio de 6.4 días (Cuadro 2).

Larvas: Las larvas de ambas especies son muy similares, de forma ortosomática y de color crema, con cabeza y una placa anal quitinizada de color café oscuro. Al momento de la muda la placa es bastante clara, casi del mismo color que el resto de la larva, pero luego se torna oscura, dependiendo de la edad, hasta adquirir la tonalidad caracteristica.

La cabeza presenta una sutura epicraneal en forma de V invertida y setas que se distribuyen en ella. El labrum está perfectamente diferenciado del clípeo, e igualmente la mandíbula de ambas especies es de forma palmeada con cuatro dientes en su margen distal. El tórax presenta 3 pares de patas con 4 segmentos cada una, terminadas en una uña o tarsunguli. El abdomen está dividido en 10 segmentos subdivididos en repliegues y setas bien demarcadas (Figura 1). Dorsalmente al noveno segmento abdominal se encuentra la placa anal y en ella dos pares de glándulas (un par en cada lado) y setas que permiten hacer una diferenciación rápida entre las dos especies: en *D. balteata* hay 6 pares de setas mientras que en *C. facialis* hay solo 4 (Figura 2). El último segmento abdominal está transformado en una falsa pata que es hábilmente utilizada en la locomoción.

En ambas especies se encontraron tres instares (Cuadro 3), en cada uno de los cuales *D. balteata* midió 0.24, 0.36, 0.53 mm de ancho de la cápsula cefálica, y *C. facialis* 0.24, 0.35 y 0.50 mm de ancho de cápsula cefálica, respectivamente.

La duración del desarrollo de las larvas en *C. facialis* varía entre 9 y 12 días y en *D. balteata* entre 12 y 15 días (Cuadro 2). La duración de cada instar es parecida en ambas especies. En *C. facialis* el primero dura de 3 a 4 días, el segundo 2 a 3 días y el tercero de 4 a 5 días. En *D. balteata* el primero dura de 3 a 4 días, el segundo 3 días y el tercero de 6 a 8 días.

En observaciones de invernadero se encontró que las larvas de *C. facialis* y de *D. balteata*, producen severos daños en plantas de frijol menores de 7 días, destruyendo el embrión, los cotiledones y los puntos de crecimiento; esto puede dar lugar a mala germinación y/o muerte de la plántula.

Prepupas: En este estado las larvas de ambas especies dejan de comer y se acortan un poco en su longitud, se inicia un engrosamiento y los movimientos se hacen cada vez más lentos hasta quedar quietas. Cuando llegan a este estado han adquirido la forma de un cayado, pero las demás características se conservan iguales a las de la larva. Este periodo varia entre 3 y 5 días en *D. balteata* y entre 2 y 5 en *C. facialis* (Cuadro 2).

Pupas: Son de forma exarata. Los élitros y las alas están ligeramente desplazadas unas sobre las otras y recubren una parte del abdomen. Tanto el fémur

Cuadro 2. **Duración del desarrollo de los estados inmaduros de *D. balteata* y *C. facialis* bajo condiciones de laboratorio (27°C; 80% H. R.).**

Estado	No. observaciones	Duración (días)			
		D. balteata		*C. facialis*	
		Ambito	Promedio	Ambito	Promedio
Huevo	2 200	5 – 7	5,1	6 – 7	6,4
Primer instar	80	3 – 4	3,7	3 – 4	3,5
Segundo instar	60	3 – 3	3,0	2 – 3	2,6
Tercer instar	130	6 – 8	7,3	4 – 5	4,5
Prepupa	172	3 – 5	4,8	2 – 5	2,9
Pupa	172	6 – 9	6,9	5 – 9	6,4
TOTAL	2 814	26 – 36	30,8	22 – 33	26,3

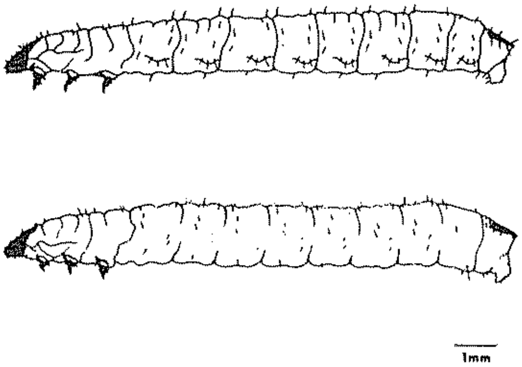

Fig. 1. Vista lateral de larvas de tercer instar. A. *Diabrotica balteata*; B. *Cerotoma facialis*.

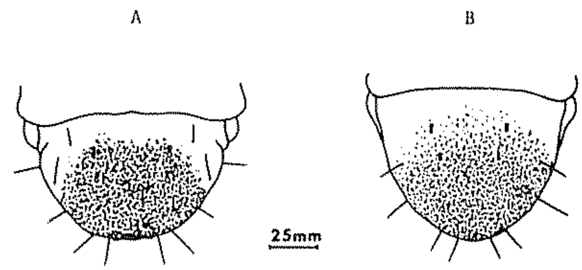

Fig. 2. Vista dorsal de placas anales en larvas de crisomélidos: A. *Diabrotica balteata* B. *Cerotoma facialis*

como la tibia de los dos primeros pares de patas están expuestos transversalmente sobre los primeros segmentos abdominales. El par de patas posteriores se extiende por debajo de los élitros y entre el fémur y la tibia se dobla formando un codo dorsal y ventralmente visible. Los tarsos de los tres pares de patas se juntan y extienden longitudinalmente a la parte ventral separando las alas de cada lado (Figura 3).

Los ojos son ligeramente café; de la parte inferior de éstos se desprende una antena de 11 segmentos que se prolonga hacia la parte posterior. Esta estructura permite distinguir los machos de las hembras de *C. facialis*; en los machos existe una modificación del tercer y cuarto segmento antenal en forma de pinza mientras que en las hembras la antena es completamente filiforme y un poco más corta (Figura 6). En *D. balteata* no se presenta esta diferencia, pero en la pupa hembra se distingue un par de glándulas situadas ventralmente en la parte posterior del abdomen.

En *D. balteata* la antena se extiende por debajo de los dos pares de patas anteriores, doblándose hacia la parte media; en *C. facialis* esta pasa únicamente por debajo del primer par de patas (Figura 3).

Una diferencia muy notable entre las dos especies es la forma del clípeo, del labrum y de las mandíbulas, ya que en *C. facialis* el clípeo es más grande y las mandíbulas se juntan a él. En el segmento caudal las pupas presentan un par de espinas ligeramente curvas.

En la culminación del estado de prepupa, mediante movimientos de contorsión se empieza a formar el "cocon" de la futura pupa, utilizando para ello material del mismo suelo donde completa su desarrollo hasta adulto. Parece ser que la humedad es un factor importante en la emergencia de los adultos; cuando es baja, puede ocasionar disminución de la emergencia. Esto puede jugar un papel importante en el aumento y disminución de las poblaciones naturales. La duración del estado de pupa fue de 6 a 9 días para *D. balteata* y de 5 a 9 días para *C. facialis*.

Cuadro 3. Anchos de cápsula cefálica y longitudes de larvas de *C. facialis* y *D. balteata* obtenidas en condiciones de laboratorio. (27°C; 80% H. R.).

Instar	Especie	No. de observaciones	Ancho de cápsula (mm)		Longitud (mm)	
			Ambito	Promedio	Ambito	Promedio
Primero	*C. facialis*	40	0.21 – 0.27	0.24	1.45 – 3.50	3.80
	D. balteata	40	0.21 – 0.25	0.24	1.43 – 4.6	3.20
Segundo	*C. facialis*	30	0.32 – 0.38	0.35	3.30 – 6.8	5.80
	D. balteata	30	0.34 – 0.40	0.36	3.62 – 8.13	5.85
Tercero	*C. facialis*	50	0.45 – 0.52	0.50	6.10 – 11.10	8.60
	D. balteata	80	0.51 – 0.57	0.53	6.17 – 12.84	10.5

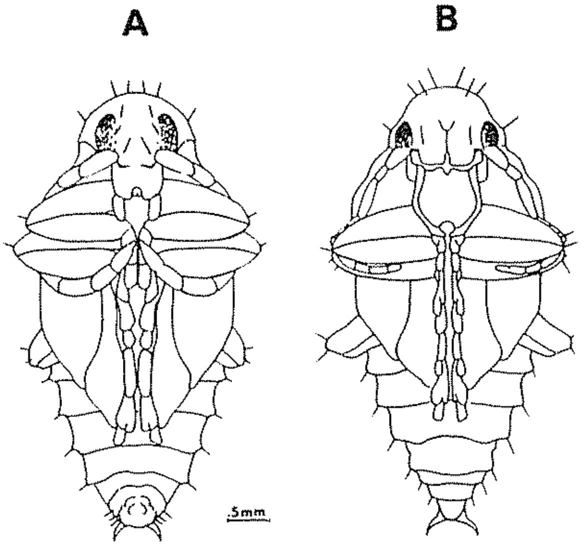

Fig. 3. Vista ventral de pupas de : A. *Diabrotica balteata* B *Cerotoma facialis*

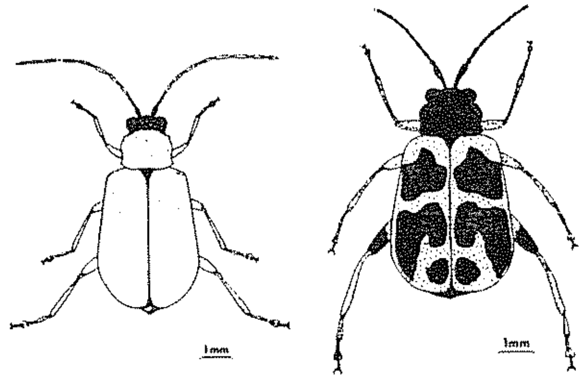

Fig. 4. Adultos de *Diabrotica balteata* (izquierda) y *Cerotoma facialis* (derecha).

Adultos: Son bastante diferentes en cuanto a color. Los de *D. balteata* presentan cabeza rojiza, tórax dorsalmente verde, pero con basisterno negro. Del tórax se desprenden tres pares de patas cuyas coxas y fémures son ligeramente verdes, las tibias y los tarsos son de color ámbar; los élitros son verdes con bandas de color amarillo. Al momento de la emergencia el color es muy opaco (color ceniza); algunos adquieren un color casi amarillo, pero con el tiempo se tornan del color descrito inicialmente (Figura 4). Los machos se diferencian de las hembras por la figuración del último segmento abdominal (Figura 5).

C. facialis tiene cabeza, tórax y abdomen de color completamente negro. Las patas son de color amarillo ámbar, con un área negra en el extremo del fémur de las patas posteriores. Los élitros son del mismo color que las patas pero con áreas negras bien diferenciadas (Figura 4). La forma y distribución de éstas áreas origina tres variaciones fenotípicas: en un caso existen tres áreas, en otro dos de éstas se fusionan y en un último caso las tres áreas se vuelven vestigiales. Ambas especies poseen un aparato bucal masticador y antenas de 11 segmentos. Estas últimas se utilizan para diferenciar machos de hembras en *C. facialis* (Figura 6).

El tamaño de los adultos es muy parecido. Machos de *D. balteata* obtenidos en condiciones de laboratorio midieron 4.3 a 5.9 mm de longitud y 2.8 a 3.4 mm de ancho. En *C. facialis* estas dimensiones fueron: 4.5 a 5.9 mm y 2.7 a 3.4 mm, respectivamente. En general las hembras de ambas especies son más grandes que los machos y la relación entre los dos sexos es aproximadamente 1:1. En *C. facialis* el 48.5% de los individuos emergidos fueron hembras.

Según la literatura, la cópula puede durar horas y durante este tiempo las hembras se desplazan caminando; la duración influye en la fertilidad de los huevos. En este estudio no se obtuvo datos para estas dos especies. Lew y Ball (10) encontraron que en *Diabrotica virgifera* LeConte las hembras que reciben espermatoforo y el porcentaje de ellas conteniendo espermatozoarios en la espermateca, se incrementa directamente con la duración de la cópula. Un prolongado período copulatorio de cerca de 3 a 4 horas es necesario para la inseminación máxima de *D. virgifera*, el cual copula una vez. Los espermatoforos inseminados en la hembra son gradualmente degenerados y desaparecen 7 días después de la cópula. Los espermatozoarios se conservan viables en la espermateca cerca de 40 días después de la cópula. Una vez culminada la cópula, los primeros huevos fértiles pueden aparecer después de 1 ó 2 días (Lew y Ball, 10).

En *D. balteata* el periodo de preoviposición varía de 9 a 12 días. Parece ser que el alimento influye mucho en la cantidad de huevos que colocan las hembras. Pulido y López (13) aseguran que el número de huevos/día de hembras alimentadas con follaje, flores y vainas tiernas de soya y rebanadas de papa, fue de 10 a 68 alcanzando un total de 1 225 como máximo y 300 como mínimo por hembra durante toda su vida. Las flores parecen muy importantes en la dieta de las hembras.

Para *C. facialis* el periodo de preoviposición varió de 5 a 7 días, y las hembras colocaron entre 14.9 y 23.7 huevos por día, cuando se alimentaron con hojas, flores y vainas tiernas de frijol. El total máximo de huevos por hembra fue de 532.

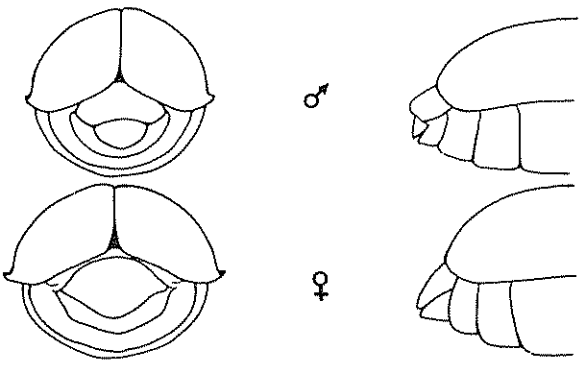

Fig. 5. Dimorfismo sexual en adultos de *Diabrotica balteata* A. vista posterior. B. Vista lateral.

En condiciones de invernadero, la longevidad promedio de *D. balteata* fue de 37 días (ámbito: 29-46) y la de *C. facialis* fue de 52 días (ámbito: 38-62). En promedio los adultos de *Diabrotica* consumieron 0.50 cm^2 de follaje/día con un máximo de 1.88 cm^2; el consumo máximo de *Cerotoma* fue de 1.94 cm^2/día para un promedio por adulto de 0.44 cm^2/día. En las dos últimas semanas de vida de los adultos el consumo foliar se reduce significativamente.

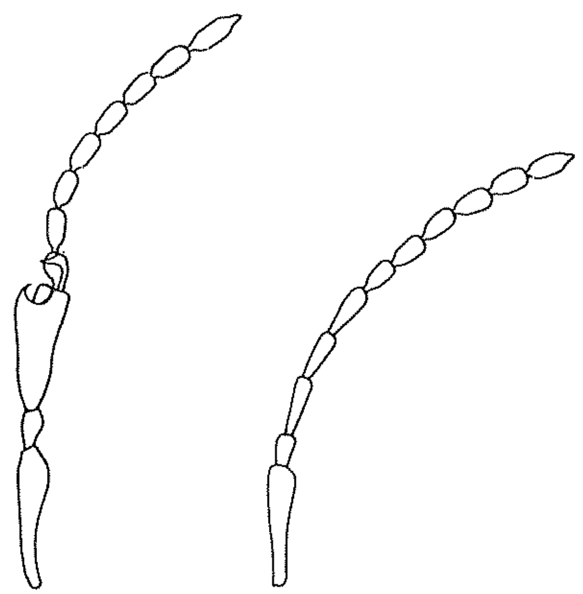

Fig. 6. Antenas de adultos de *Cerotoma facialis*. A. Macho; B. Hembra.

Resumen

Se describe la morfología, biología y hábitos de los crisomélidos *Diabrotica balteata* y *Cerotoma facialis* Erickson, plagas del frijol común, bajo condiciones de laboratorio (27°C y 80% H. R.) y estudios de invernadero. Se encontró que las larvas de *D. balteata* no sobreviven cuando se alimentan con raíces de frijol mientras que larvas de *C. facialis* no atacan plántulas de maíz. Los huevos de *D. balteata* y *C. facialis* demoran un promedio 5.1 y 6.4 días, respectivamente. Ambas especies presentan tres instares larvales con una duración de 14 días en el caso de *D. balteata* y 10.6 en el caso de *C. facialis*. La pupa forma una célula en el suelo y este estado dura de 6 a 7 días. Para ambas especies la relación de sexo fue 1-1. Hembras alimentadas con hojas de frijol vivieron 37 días (*Diabrotica*) y 52 días (*Cerotoma*). En ambas especies el período de preovulación varió entre 5 y 12 días. El máximo de huevos producidos por adultos de *D. balteata* alimentadas con hojas de frijol fue de 144 por hembra y para *C. facialis* fue de 532 huevos. Ambas especies consumieron más follaje durante las primeras dos semanas de su ciclo de vida.

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FRUIT CHARACTERISTICS IN *Cola acuminata*: I. POD WEIGHT, NUT WEIGHT AND NUT NUMBER[1] /

*MICHAEL A. O. OLADOKUN**

Resumen

Las mazorcas frescas de Cola acuminata *se clasificaron por su peso, número de semillas y peso total de las semillas por mazorca. El peso de las mazorcas varió entre 30 y 550 g, la mayoría de ellas con un peso entre 101-200 y (43.11%) y un peso promedio de 209 g.*

El 53.85% de las mazorcas presentó entre 6-10 semillas mientras que el 24.33% y el 21.82% de las mismas presentó entre 1-15 y 11-15 semillas por mazorca, respectivamente. El promedio de semillas por mazorca fue de 7.9. La mayoría de las mazorcas tuvieron un peso de semillas entre 26 y 125 g con un peso promedio de semilla por mazorca de 88 g.

En el análisis estadístico se encontró diferencias significativas al 0.1% para el peso por mazorca, el peso total de semillas por mazorca, y el número de semillas. El efecto de la localidad de la plantación no fue significativa. Las interacciones entre el peso de la mazorca y el peso total de semillas por mazorca, el peso de la mazorca y el número de semillas, el peso total de semillas por mazorca y el número de semillas, peso total de semillas por mazorca y la localidad de la plantación, y el número de semillas y la localidad fueron significativas al 0.1% mientras que las interacciones entre el número de semillas, el peso total de semillas por mazorca y peso de mazorca, número de semillas, peso total de semillas por mazorca y localidad, y peso total de semillas por mazorca, peso de mazorca y localidad fueron significativas, las interacciones entre el número de semilla, el peso de la mazorca y la localidad no fueron significativas.

Introduction

The two most common species of the genus *Cola* are *Cola nitida* and *Cola acuminata. C. nitida* has, however, enjoyed greater popularity than *C. acuminata* both in commercial context and usage (Russell, 12; Eijnatten, 3; Ibikunle, 6). Similarly, much research work has been done on *C. nitida* to the total neglect of *C. acuminata.* Thus apart from taxonomic identification parameters, little or no information exists on its biology and cultivation.

However, this situation may soon change for better for *C. acuminata.* In February 1977, a survey of *C. acuminata* in Zaire was sponsored by an American company to evaluate the commercial viability of a Kola processing factory based on its production (Eijnatten, 4). Thus, soon, there will be a need to increase both its hectareage and productivity. An attempt at these two objectives can only succeed through well planned and executed selection and breeding programmes.

Quite a good deal of work has been done on selection in *Theobroma* cacao which belongs to the same family Sterculiaceae as *Cola.* Ruinard (11) stated that the total annual pulp production and the average weight of seeds are among the most important criteria in selecting new parent trees in a seedling population

1 Received for publication on July 14, 1981.

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of cocoa. As early as 1967, Toxopeus and Jacob (7) and Toxopeus and Wessel (14) carried out pod and bean values studies on hand pollinated cocoa in Nigeria. The authors state that the number of beans in a cocoa pod is a component of pod value and as such is important yield factor. Similar studies on cocoa have been carried out by Atanda and Jacob (1) and Jacob and Atanda (7) who stated that, though pod production and pod value are two important yield components in cacao, pod value studies give finer details of yield characteristics than pod production. Most progeny and clonal trials in *C. nitida* are evaluated on the bases of total yield, nut number and nut weight per pod (Olaniram *et al.*, 10).

It is therefore necessary to start building up an informative picture on *C. acuminata* to facilitate a quick reference on the type and extent as well as the sources of variability of certain characters that are of importance in its crop selection and improvement. This paper is therefore the first in the series aimed at amassing information on *C. acuminata*.

Materials and method

Fresh pods of *C. acuminata* purchased directly from the farms and rural markets in Oyo and Ondo States were brought into the laboratory for processing. The pods were weighed individually and their length and girth were measured with vernier calipers. Individual pods were then split open and the number of the nuts per pod recorded. The nuts from each pod were first weighed while still covered with the testa. Each nut was then skinned and its final weight recorded.

From the data collected, percentage compositions by the pod husk, testa and nuts were worked out. The pods and the nuts were sorted out into weight classes as well as nut number classes and the number of pods occurring in each subclass was recorded. Finally, a three-way statistical analysis was carried out to determine some possible linkage among the three factors, pod weight, total nut weight per pod and nut number per pod.

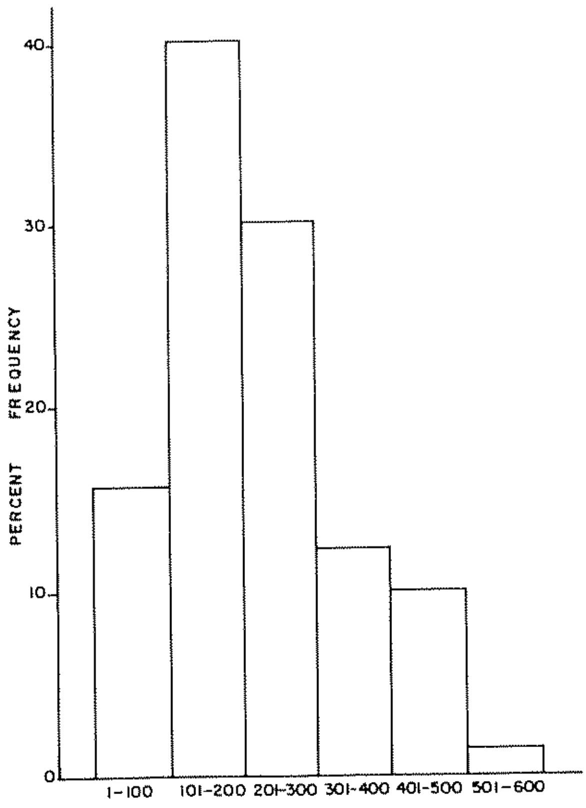

Fig 1. Percent frequency distribution of *Cola acuminata* pods on pod weight basis

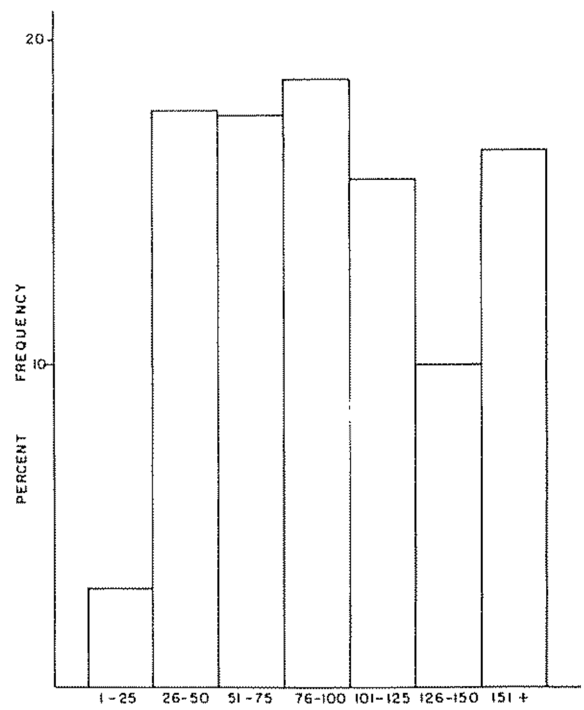

Fig 2. Percent frequency distribution of *Cola acuminata* pods on total nut weight per pod basis.

Results

Pod weight class of 101-200 g resulted in the highest number of pods while that of 501-600 g size had the least (Figure 1). 70% of the total 919 pods considered occurred between 101-300 g weight, the mean pod weight being 209 g. The least in the total nut weight per pod distribution was 1-25 g size class while the highest was 76-100 g size class (Figure 2). Mean total nut weight per pod was 88 g. The highest number of pods contained 6-10 nuts per pod (Figure 3). The least number of pods was recorded by 11-15 nut number class while the mean nut number was 7 9

The pods from various locations (Figure 4) showed some slight differences with respect to pod weight distribution. While the pods from Ifewara were mostly light and small ones, the ones from Oke Agbe tend to be heavier. 101-200 g pod weight class accounted for at least 45% of the pods in the two of three locations considered, the exception bein Oke Agbe where 32.28% was recorded for that weight class.

The pods from Ifewara and Ondo were much more heavily distributed between 26 and 125 g weight class than those from Oke Agbe, where the pods were highly concentrated in heavier weight classes (Figure 5). Thus the nuts from Oke Agbe were relatively heavier than those obtained in other locations

In all the locations, 6-10 nut number class recorded the highest percentage scoring more than 50% in each location (Figure 6) except at Ondo where slightly less than 50% was recorded It is interesting to observe that in spite of heavier total nut weight per pod recorded for Oke Agbe, the majority of the pods have relatively lower nut number per pod, 91% having 1-10 nuts per pod.

Analysis of variance carried out on the data for all the locations showed that the effects of location as well as the second order interaction among pod weight, total nut number and location were not significant (Table 1). However, the interactions between pod weight and location, total nut weight per pod and location as well as nut number and location were significant. These are well illustrated in Figures 4 to 6. The effects of other main factors viz: pod weight, total nut weight per pod and total nut number as well as their interactions were significant ($P = 0.001$).

Multiple correlation and regression analyses were run among some of the pod characteristics. Table 2 shows the pairwise tabulation of the correlation coefficient factors while the regression curves for some of the significant regression analyses are shown in Figures 7 to 11. Table 3 shows the mean values of the pod characteristics.

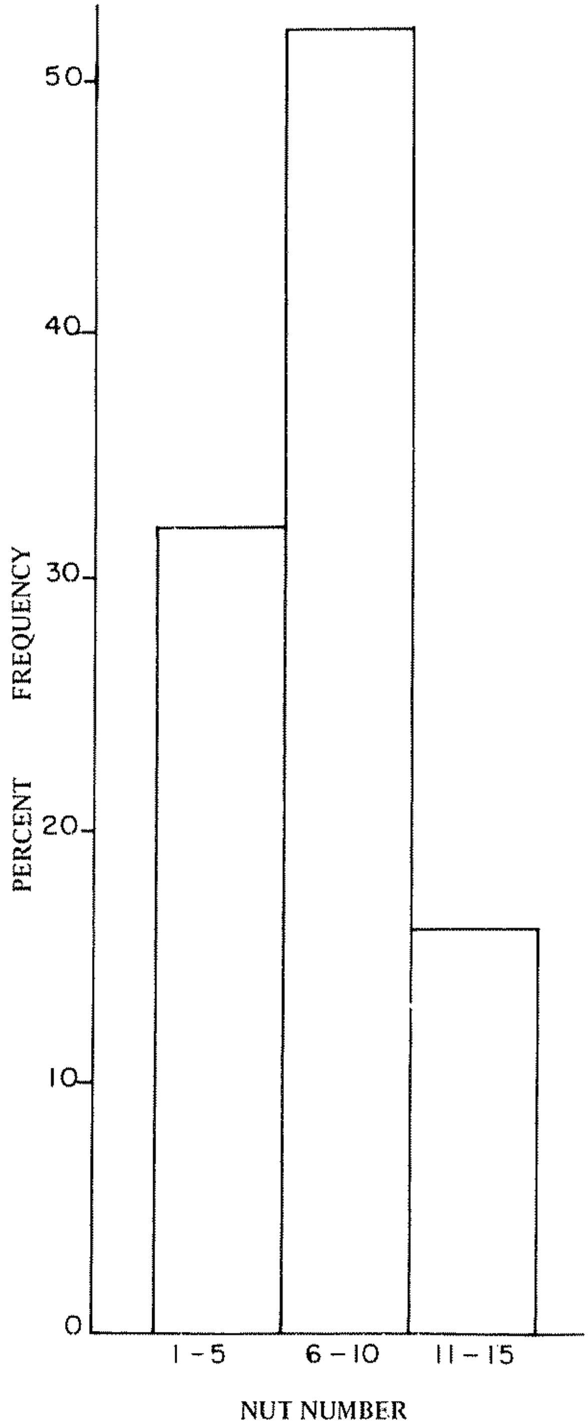

Fig. 3. Percent frequency distribution of *Cola acuminata* pod on nut number basis.

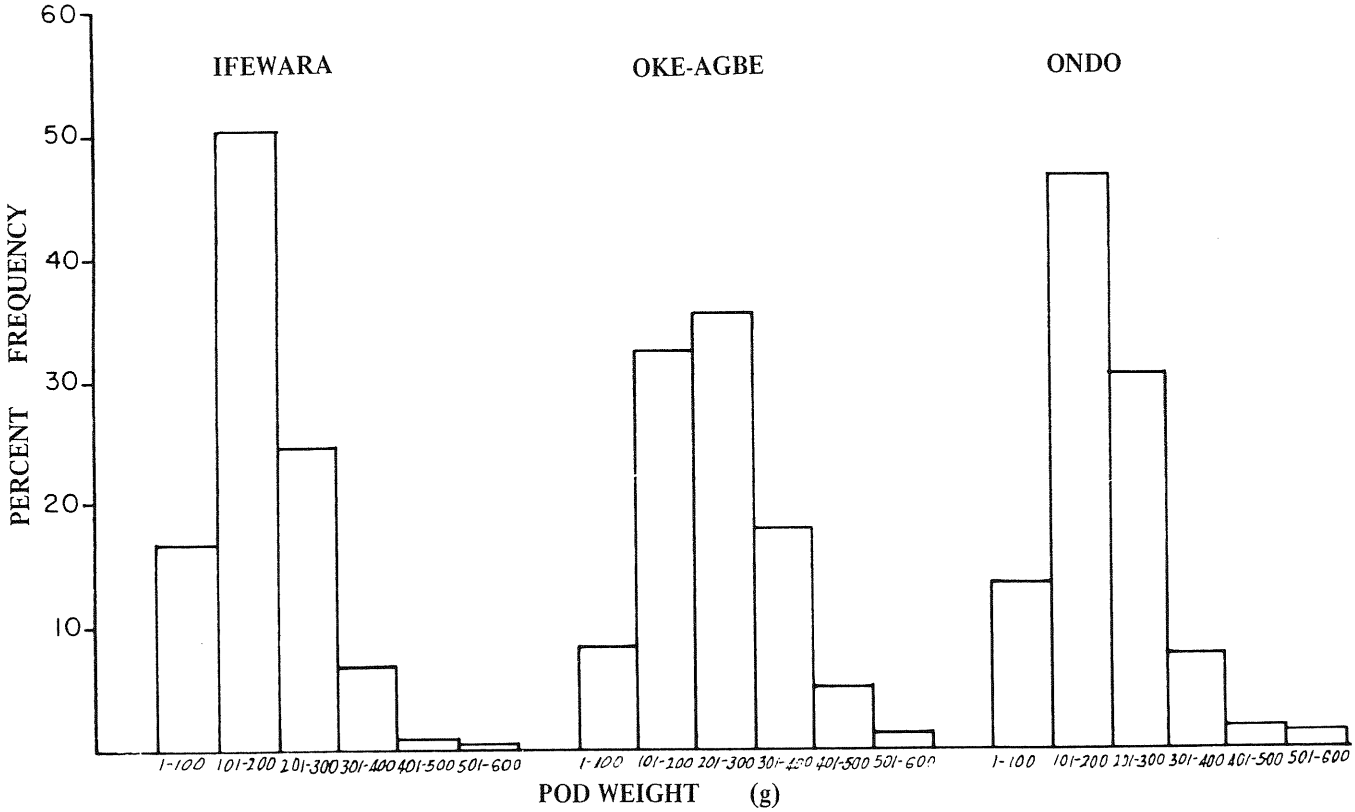

Fig. 4. Variation of *Cola acuminata* pod weight distribution with location.

Table 1. Analysis of variance table on the arcsin-transformed data of pod weight, total nut weight per pod, total nut number per pod and locations in *Cola acuminata.*

Sources of variation	D.F.	S.S.	M.S.	F	SIG. LEVEL
Pod weight (P)	5	1 547.82	309.565	91.00	* * *
Total nut weight (T)	6	287.547	47.924	14.09	* * *
Total nut number (N)	2	185.972	92.986	27.33	* * *
Location (L)	2	1.410	0.705	0.21	NS
P x T Interaction	30	3 129.732	104.324	30.67	* * *
P x N Interaction	10	224.386	22.439	6.60	* * *
P x L Interaction	10	79.159	7.916	2.33	*
T x N Interaction	12	168.859	14.072	4.14	* * *
T x L Interaction	12	186.445	15.537	4.57	* * *
N x L Interaction	4	57.622	14.405	4.23	* * *
P x T x N Interaction	60	385.756	6.429	1.89	* * *
P x T x L Interaction	60	395.615	6.593	1.94	* * *
T x N x L Interaction	24	168.835	7.035	2.07	* *
P x N x L Interaction	20	86.119	4.306	1.26	NS
Residual (P x T x N x L)	120	408.198	3.402	–	–
TOTAL	377	7 313. 481	–	–	

*** Significant at 0.1%. * Significant at 5.0%.

** Significant at 1.0%. NS Not significant.

Table 2. Linear correlation coefficients of some characteristics of *Cola acuminata* pods.

	Pod weight	Pod length	Pod girth	Nut number	Nut weight	Testa weight	Pod husk weight	Pod length / Pod width	No. of red nuts	No. of pink nuts	No. of white nuts	Percent pod husk weight	Percent nut weight	Percent testa weight
Pod weight	–	0.48***	0.28**	0.23*	0.89***	0.67***	0.88***	0.21*	0.17	0.00	0.20*	0.21*	0.14	0.13
Pod length		–	0.57***	0.43***	0.35***	0.31**	0.51***	0.37**	0.15	0.30**	0.17	0.04	0.06	0.07
Pod girth			–	0.21*	0.10	0.20*	0.39***	–0.51***	–0.06	0.32**	0.12	0.21	–0.24*	0.09
Nut number				–	0.26**	0.20*	0.14*	0.19*	0.69***	0.33***	0.07	–0.27**	0.19*	0.17
Nut weight					–	0.54***	0.61***	0.27**	0.21*	0.01	0.15	–0.52***	0.51***	0.03
Testa weight						–	0.48***	0.10	0.15	0.01	0.11	–0.32**	–0.02	0.76***
Pod husk weight							–	0.12	0.09	0.00	0.21	0.21*	–0.23*	0.02
Pod length / Pod width								–	0.22*	–0.07	0.04	–0.17	0.20*	–0.04
No. of red nuts									–	–0.43***	–0.21*	–0.19*	0.13	0.14
No. of pink nuts										–	0.10	–0.09	0.08	0.03
No. of white nuts											–	0.00	0.00	–0.01
Percent pod husk weight												–	–0.89***	–0.28**
Percent nut weight													–	–0.15
Percent testa weight														–

*** Significant at 0.1%.
** Significant at 1.0%.
* Significant at 5.0%.

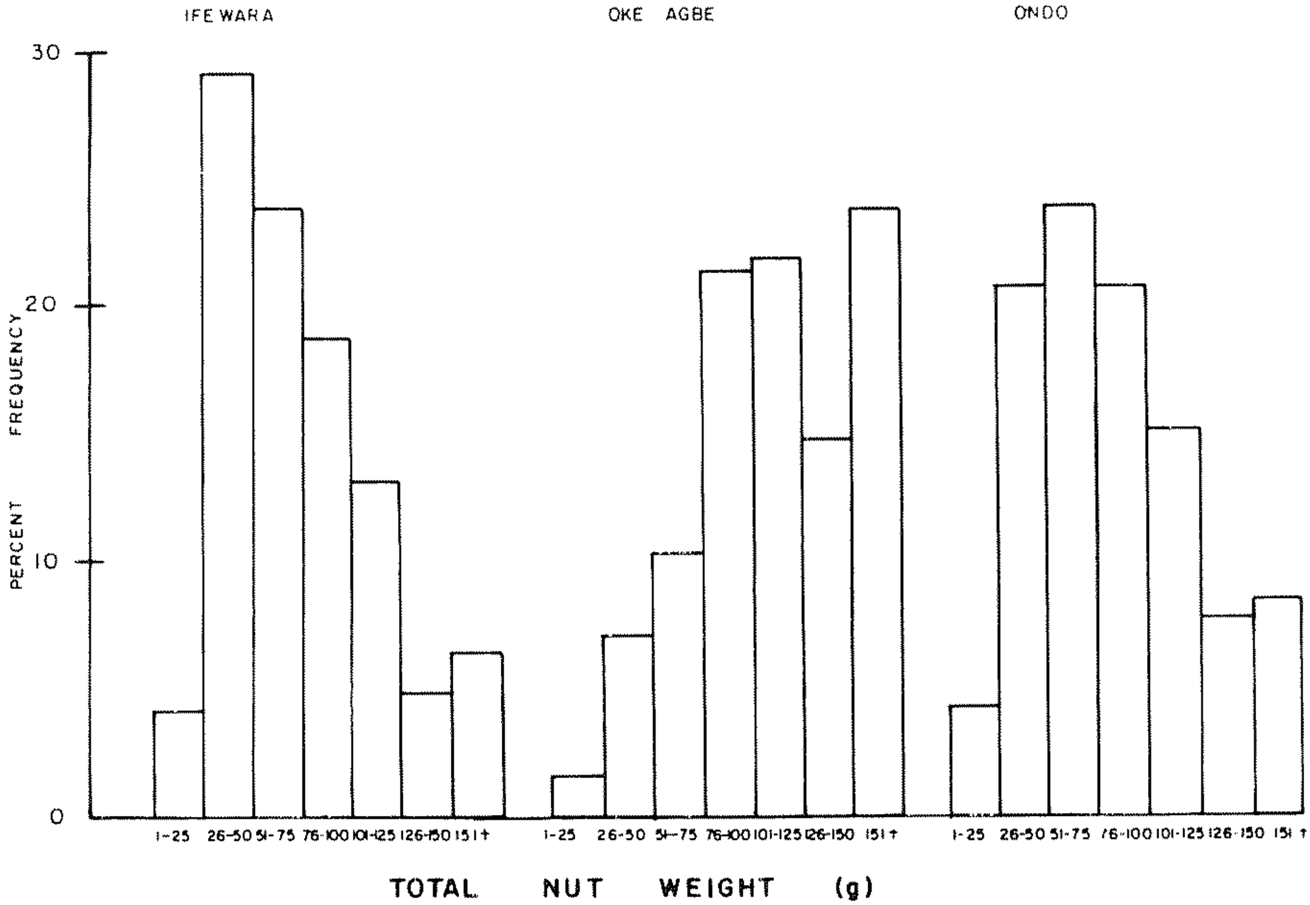

Fig. 5. Variation of *Cola acuminata* total nut weight per pod distribution with location.

Discussion

The highest frequency of pods occurred between 101 and 300 g weights, while the majority of pods have between 26 and 125 g weights for the total nut weight content. The nuts at the extreme ends of the pods were found to be smaller than the ones in the middle as reported for *C. nitida* by Eijnatten (3). The average pod weight was found to be 209 g, while the mean total nut weight per pod was 88 g.

It is significant to note that increase in pod weight was much more due to increase in nut weight than that which was due to increase in nut number. This is well illustrated in Figures 4 and 5 where heavy pod weight recorded for Oke Agbe was rather due to heavy nuts contained by the pods. Table 2 and Figure 9 also show that the correlation and regression between total nut weight per pod and pod weight were very highly significant. This is in agreement to what was obtained in cocoa where the increase in pod weight was accounted for jointly by both

Table 3. Mean values of pod characteristics of *Cola acuminata*

Characteristics	Mean Values[1]
Pod weight (g)	208.66 ± 93.97
Pod length (cm)	15.13 ± 2.85
Pod girth	16.70 ± 3.35
Nut number per pod	7.86 ± 2.86
Total Nut weight per pod (g)	88.22 ± 47.72
Testa weight (g)	21.01 ± 15.19
Pod husk weight (g)	99.43 ± 46.05
Pod length / Pod width	1.85 ± 0.37
Number of red nuts	3.01 ± 2.02
Number of pink nuts	6.67 ± 3.18
Number of white nuts	0.16 ± 0.62
Percent pod husk weight	49.00 ± 9.74
Percent nut weight	41.27 ± 9.51
Percent testa weight	9.70 ± 4.65

1 Each figure is a mean of 919 pods.

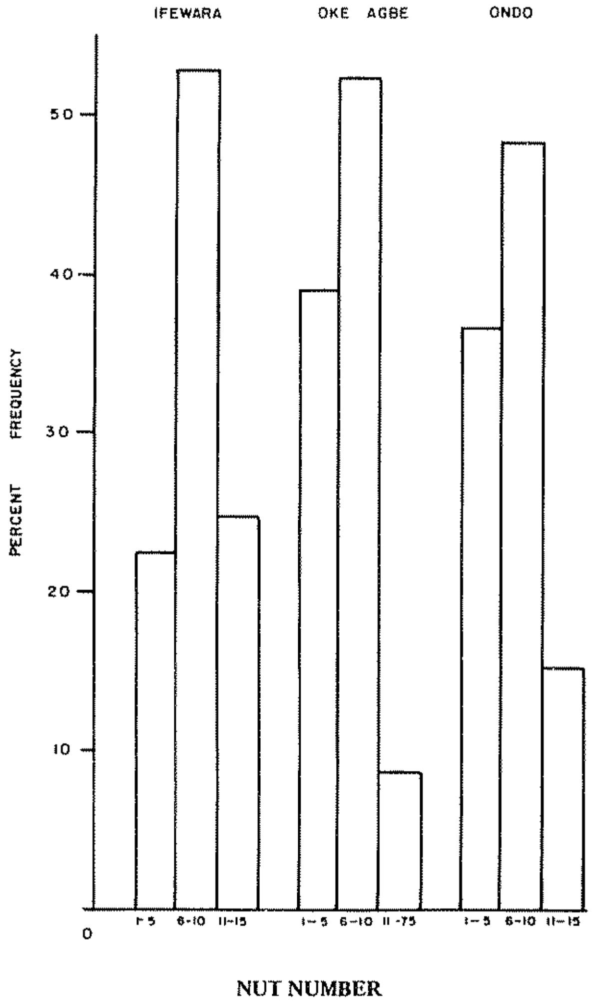

Fig. 6. Variation of *Cola acuminata* nut number per pod distribution with location.

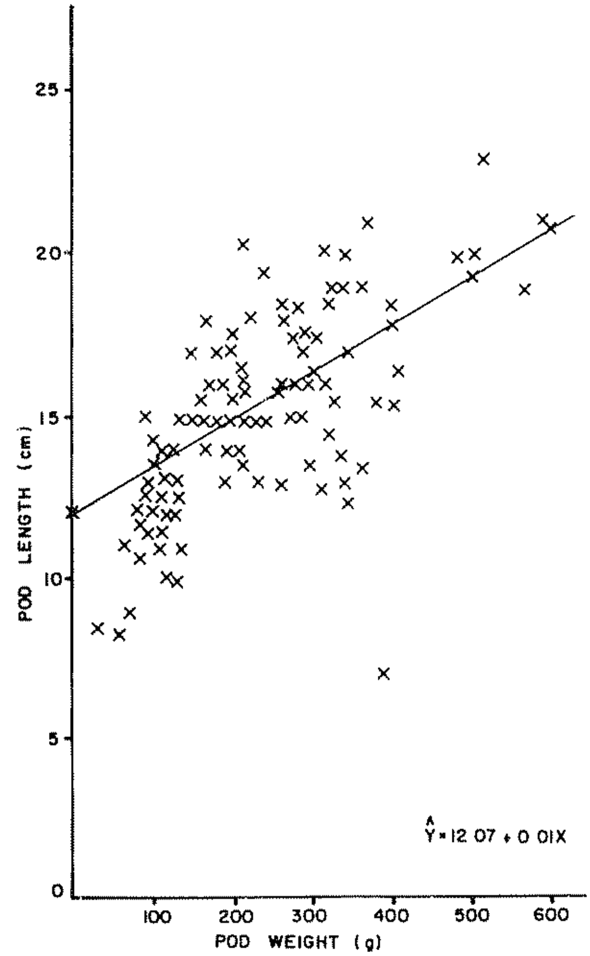

Fig. 7. Regression curve of pod length with pod weight in *Cola acuminata*.

the increase in the number of seeds and increase of the average weight per seed (Ruinard, 11), although the author did not specify which one of the factors predominated. The regression curves of nut number and total nut weight per pod and per cent nut weight with pod weight (Figures 8 and 9) showed that there is a minimum size the pod must have to contain minimum sizeable nuts. The curves also showed that although a given pod may contain nuts in good condition and may have reasonable size, the nuts may be entirely testa or too small to be economically useful. This phenomenon is not unknown with kola pods.

The highest nut number per pod obtained was 13, while the least was 1. This and the fact that the majority of the pods had between 6 and 10 nuts per pod agree with those of Keay *et al.* (8), Russell (12), but disagree partially with Hutchinson and Dalziel (5) who put the nut number at 1-9. Dublin (2) recorded an average of 7.2 nuts per pod for *C. nitida* with a range of 1-15 nuts per pod. His findings thus agree well with these results as the mean nut number per pod recorded here was 7.9.

The highly significant interactions recorded for nut number and location, total nut weight per pod and location, and the slight significance of the interaction between the pod weight and location underscore the variability of these characters from one location to the other and at the same time foreshadow the likely genetic variability involved barring any distinct edaphic soil factors. The three characters (pod weight, total nut weight per pod

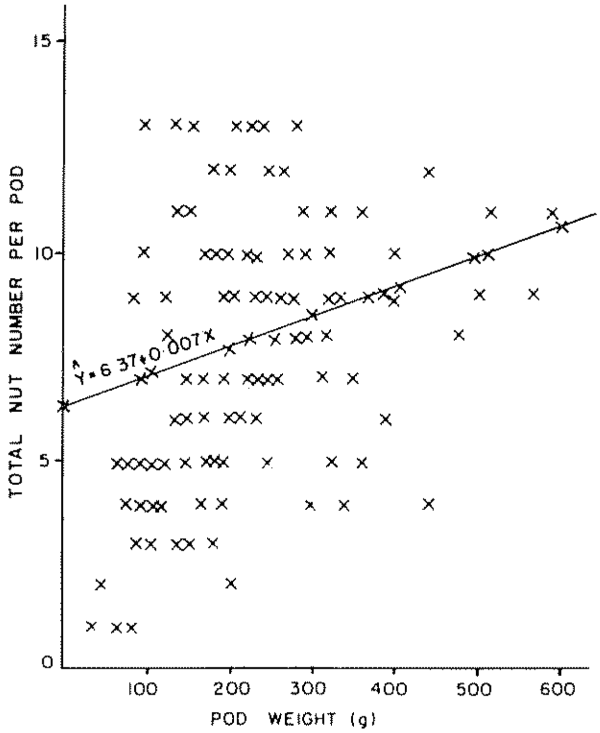

Fig. 8. Regression curve of total nut number per pod with pod weight *in Cola acuminata*.

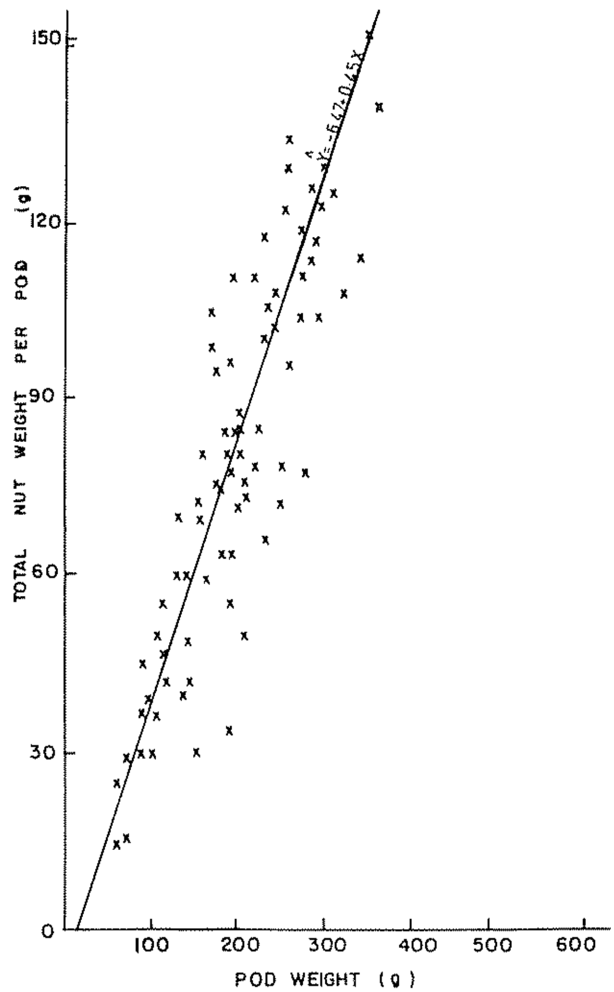

Fig. 9. Regression curve of total nut weight per pod with pod weight in *Cola acuminata*.

as well as total nut number per pod) show a highly significant interaction. It is noteworthy that of the four main factors, i.e. pod weight, total nut weight per pod, total nut number per pod and location, only the latter was not significant. This further shows that the differences and interactions recorded for the characters are mostly likely to be genetically controlled.

Pod weight correlated positively with its three components viz: nut weight, testa weight and pod husk weight and the correlations were highly significant though nut weight and pod husk weight were equaly but much more significant than testa weight. Pod weight was also significantly correlated with pod length and pod girth but slightly with nut number. This is not surprising as the size of the pod dictates the pod husk weight, the latter being strongly correlated with pod weight. It is significant to note that pod weight is significantly negatively correlated with per cent pod husk. This is a welcome situation in that the fraction of the husk decreases while that of nut weight increases with increase in pod weight. In fact, per cent pod husk deservedly and highly significantly correlated negatively with per cent nut weight. Finally, it is not surprising that pod length correlated strongly with nut number since the more the number of the nuts within a pod, the longer it should be, if not wider.

The mean values of the pod characteristics tabulated in Table 3 are of tremendous value when considering the various characteristic components of a kola pod and the possibility of improving upon any of them. The mean fractional composition of pod husk, total nut weight and testa viz: 49.0%, 41.0% and 10.0% respectively, agree well with the findings of Ogutuga (9) who reported 44.3% , 40.4% and 14.30% for pod husk, total nut weight and testa respectively for *C. nitida*.

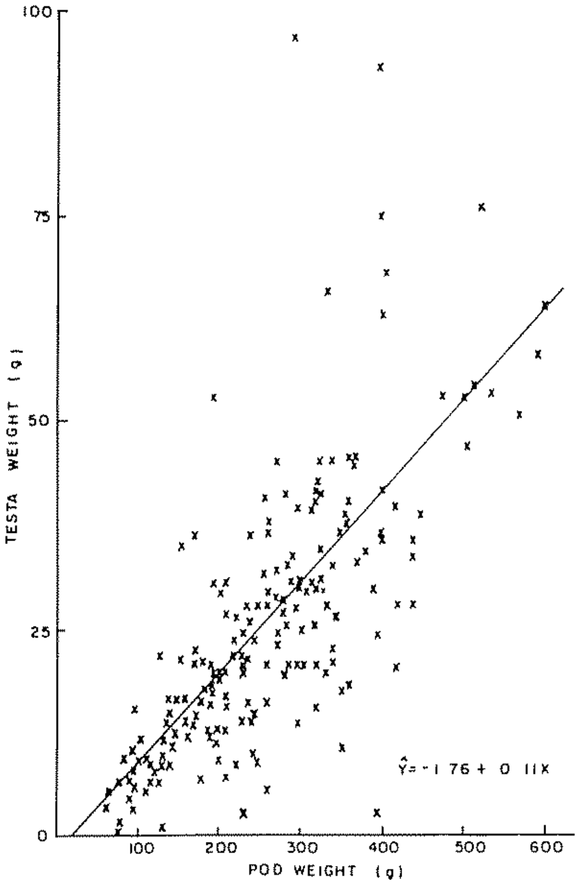

Fig. 10. Regression curve of testa weight with pod weight in *Cola acuminata*

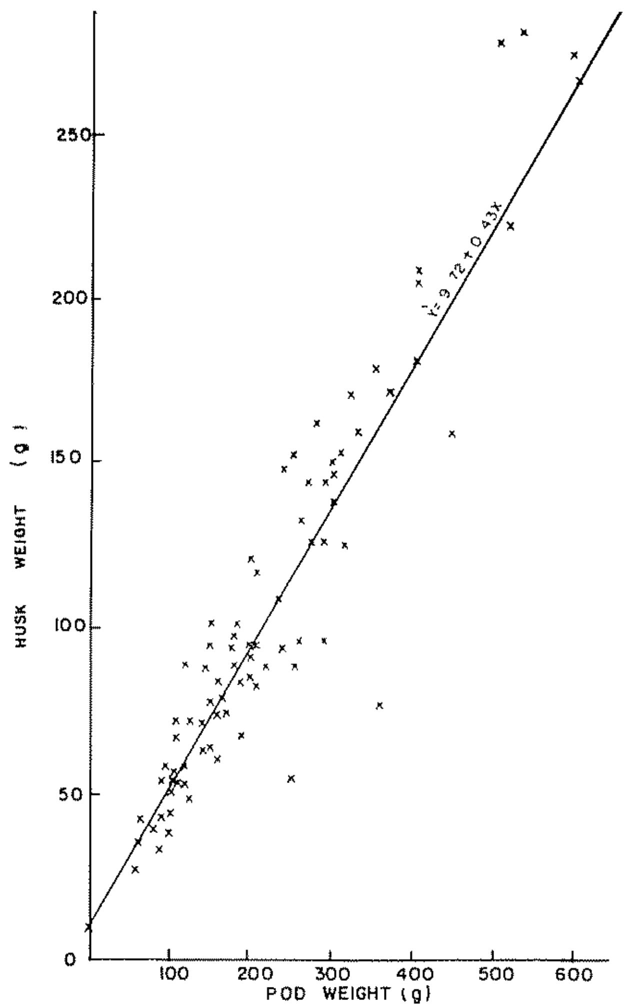

Fig. 11. Regression curve of husk weight with pod weight in *Cola acuminata*

Conclusions

The findings reported above show that *C. acuminata* pod is full of variable characters which are genetically based. As a good number of these factors interact significantly, it is very likely that a good number of them will be linked. The degree of such linkage will no doubt determine the ease, or otherwise, as well as the success of subsequent breeding programmes.

Abstract

Fresh *Cola acuminata* pods were classified into pod size, nut number and total nut weight per pod. Pod sizes varied from 30 g to 550 g with the majority of them falling into 101-200 g size (43.11%). Mean pod weight was 209 g. 53.85% of the pods have 6-10 nuts per pod while 24.33% and 21.82% have 1-5 and 11-15 nuts per pod respectively. Mean nut number per pod was 7.9 A majority of pods had total nut weight of 26 g to 125 g with average total nut weight being 88 g.

Statistical analysis gave 0.1% significant difference for pod weight, total nut weight per pod, and nut number. Planting location effect was not significant. Interactions between pod weight and total nut weight per pod, pod weight and nut number, total nut weight per pod and nut number, total nut weight per pod and location and nut number and location were also significant at 0.1% level. While the interactions between nut number, total nut weight per pod and pod weight, nut number, total nut weight per pod and location and total nut weight per pod, pod weight and location were significant, interactions between nut number, pod weight and location were not significant.

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FRUIT CHARACTERISTICS IN *Cola acuminata*: II. NUT SIZE, COTYLEDON NUMBER AND COLOUR[1] /

*MICHAEL A. O. OLADOKUN**

Resumen

Se estudió 29 428 semillas de Cola acuminata, *obtenidas de mazorcas frescas colectadas en los Estados de Oyo, Ogun y Ondo, Nigeria. Las semillas se clasificaron con base a su tamaño, número de cotiledones y color. La clase más abundante por tamaño fue de 6-10 g, seguido por la clase de 11-15 g. Los cotiledones se presentaron con mayor frecuencia en número de cuatro, indiferentemente de su color o tamaño. Las semillas rosadas se presentaron con mayor frecuencia que las rojas, mientras que las blancas representaron tan solo el 4%.*

El análisis estadístico mostró diferencia significativa al 0.1% para el tamaño, el número, el color y el origen del cotiledón, con una interacción significativa al 0.001% entre ellas. Se discute la importancia de las características mencionadas y el uso futuro de esta variabilidad en trabajos de selección futura de Cola acuminata.

Introduction

Russell (8) recognized *Cola acuminata* to have three to five cotyledons while Keay *et al.* (6) classified *C. acuminata* as that species of *Cola* with nuts of 3 to 5 cotyledons but rarely 2 or 6. Ibikunle (5), while recognizing the pleiocotyl nature of *C. acuminata,* found that germination velocity of *C. acuminata,* varies with cotyledon numbers, four and five cotyledon nuts giving the best germination rate. In the same report, he found that nuts of 11 – 15 g size had the best germination velocity. In classifying the nuts he used in the experiment into sizes, he found 11 – 15 g class size to have 28.2% frequency, followed by 6 – 10 g and 16 – 20 g class sizes with 26.3% and 22.4% frequency respectively. The least frequency of 4.5% was recorded for greater than 25 g size. However, the number of the nuts considered was rather small (only 1 433 nuts) and the classification was limited to only the nut size, leaving information on cotyledon number and colour distribution blank.

Colour variation in Kola was studied by Voelcher (9) but the study was limited to only *Cola nitida.* While he recognized the existence of three colours, red, pink and white, he found the dark red to be most common and the white comparatively rare. Most important however was his conclusion that colour of the nuts may vary from follicle to follicle, from tree to tree and on the same tree, from year to year. He believed that colour in Kola is determined by a number of genes which is complex. This partially agreed with Chamney (2) who showed variation of nut colour from year to year, and concluded that colour is a function of age and not a Mendelian character. Dublin (1) and Eijnatten (4) also confirmed the existence of these three colours, but Dublin believed the division into the three distinct colours to be quite arbitrary and unrealistic since observation on a large number of *C. nitida* nuts revealed that one can pass progressively from a deep red coloured nut to a white or creamish nut, through a range of intermediate coloration giving a wide spectrum of colour variation. Finally, Dublin (1), expressing the curiosity of several authors at this phenomenon of multiple coloration, stated that there is no known precedence of this coloration in the plant kingdom. He believed that only *C. nitida* showed the three colours, while other species such as *C. ballayi, C. acuminata* and *C. verti-*

1 Received for publication in July 20, 1981.

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cillata, have pink to pale pink nuts. Russell (8), however, recognized the three colours in *C. acuminata*.

In view of rather scanty information on *C. acuminata* (Eijnatten, 3) and imminent increase in its demand, a need arises for studies to be initiated on the species. Thus a study of nut size, cotyledon number and colour distribution in this species will give quantitative and qualitative relationships among the three factors and will thus serve as handy information for ultimate selection and breeding studies.

Materials and method

Fresh pods were bought directly both from the rural markets and the farmers on their farms. They were then split open and the nuts, covered with the testa, were soaked overnight prior to the removal of the testa. The skinned nuts were then left in the baskets so that water could drain off overnight. The nuts were sorted out into 1 – 5, 6 – 10, 11 – 15, 16 – 20, 21 – 25, 26 – 30, 31 – 35, 36 – 40 and 41 + g-class sizes. Each of these classes was then sorted out into 1, 2, 3, 4, 5 and 6-cotyledon number subclasses. The subclasses were finally sorted into red, pink and white colours. Records bases on these three factors were statistically analysed to detect both the significant differences and possible interaction among the factors.

Results

Nut size class 6 – 10 g had the highest frequency (34.8%) of the whole population of 29 428 nuts investigated (Figure 1). This was followed by 11 – 15 g size class. In all, about 90% of the whole population fell between 1 and 20 g-nut weight, while the average nut weight was 15.3 g. On the nut cotyledon number basis, four-cotyledon nuts accounted for 59.3% (Figure 2) followed by five-cotyledon nuts. More than 95% of the entire nuts sorted out had 3, 4 and 5 cotyledons, while least frequency was recorded for one cotyledon (or "akiriboto" variant) with only 0.5% . Two nuts with 7 cotyledons were observed and these are shown in Figure 9. Pink nuts outstripped the red nuts, while the white nuts had the least frequencies (Figure 3).

When the percentage distribution of the nut size with respect to location was considered, it was observed that in all the locations, the majority of the nuts fell between 1 and 20 g-size (Figure 4). However, there is a conspicuous difference in size distribution in the nuts procured from Oke Agbe. Here, 11 – 15 g-size class had the highest frequency followed by 6 – 10 g and 16 – 20 g-size classes respectively.

Except for Ijan Ekiti where three-cotyledon nuts ranked second to the four-cotyledon nuts, the trend in all the locations is four, five and three cotyledon nuts in decreasing order of abundance (Figure 5). Four-cotyledon nuts accounted for about 60% of the population in all the locations except at Ijan Ekiti where 56% was recorded.

Variation in nut colour with location seemed to be much more pronounced than experienced with nut size and nut cotyledon number (Figure 6). A similar trend of pink, red and white nuts, in decreasing order of abundance, was displayed by the nuts from Ifewara, Oke Agbe, Ondo and Ijebu Imushin. However, red nuts were in the majority at Ijan Ekiti.

Other interactions that were found to be significant at $P = 0.001$ are shown in Table 1. Figures 7 to 8 show the nuts as they vary in size and colour, while Figure 9 shows the one and seven cotyledon nuts.

Discussion

The frequency values for the various weight classification shown in Figures 1 and 4 indicate that the average nut weight of *C. acuminata* is rather low only very few weighed more than 20 g while the average was 15 g. Though this value is said to be low, it is similar to 16 g reported for *C. nitida* by Russell (8) and agrees with Eijnatten (4) who stated that weight of the *C. nitida* nuts may be up to 100 g, but usually varies from 10 – 25 g. The percentage distribution with respect to size class was similar to that reported by Ibikunle (5), although 6 – 10 g size recorded the highest frequency as against 11 – 15 g size reported by him. The frequency distribution showed a significant variation with locations, and nuts from Oke Agbe tended to be heavier than in other locations.

For the first time, a report is made of one cotyledon and seven cotyledon *C. acuminata* nuts. The occurrence of one cotyledon variant ("Akiriboto" variant) is not uncommon in *C. nitida* in the Southern part of Nigeria, but it is surprising that such a record did not exist for *C. acuminata* in all the sources on Kola taxonomy consulted so far. This variant recorded 0.53% frequency in this study.

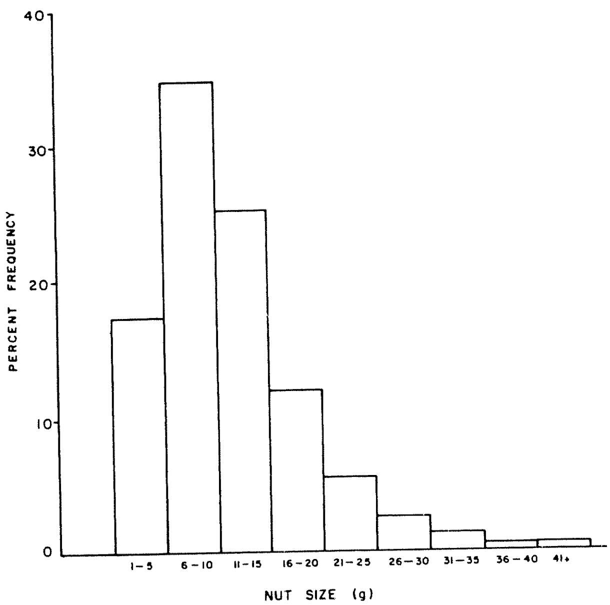

Fig. 1. Percent frequency distribution of *Cola acuminata* nuts on weight basis.

However, the seven-cotyledon variant is both uncommon and unrecorded in any available literature on Kola.

The fact that 3, 4 and 5 cotyledon nuts accounted for more than 95% of the entire nuts in this study could be viewed against the germination velocity of the various cotyledon classes as reported by Ibikunle (5) and confirmed by Oladokun (7). One can relate the natural selection influence to the frequency distribution, since the most common cotyledon types recorded the fastest germination velocity and percentage.

Colour distribution in *C. acuminata* seems to be the most variable character, with respect to nut size, cotyledon number and location. This agrees with Eijnatten (4) who stated that the most obvious variation in the nuts lies in their colour. Colour categorization may appear as simple as shown in Figure 8a, but Figure 8b shows that the exercise may not be all that simple as the graduation of colour intensity from white to dark red shows a streamlined pattern that makes the creation of colour demarcations a difficult task. Thus the wide range and graduality of colour intensity variation makes classification somewhat difficult and subjective. It tends to make such a classification favour pink as reported by Eijnatten (3).

Its variability suggests that colour variation in *C. acuminata* may not after all be a Mendelian character in agreement with Chamney (2) working with *C. nitida* in Ghana. If, however, it is a Mendelian character, Voelcker's (9) conclusion that colour in *C. nitida* is determined by a number of genes, which is itself no doubt complex, may be considered appropriate.

The existence of the three colours, red, pink and white, while disagreeing with Dublin (1) that only *C. nitida* showed the three colours, agrees with Russell (8) who reported the same phenomenon

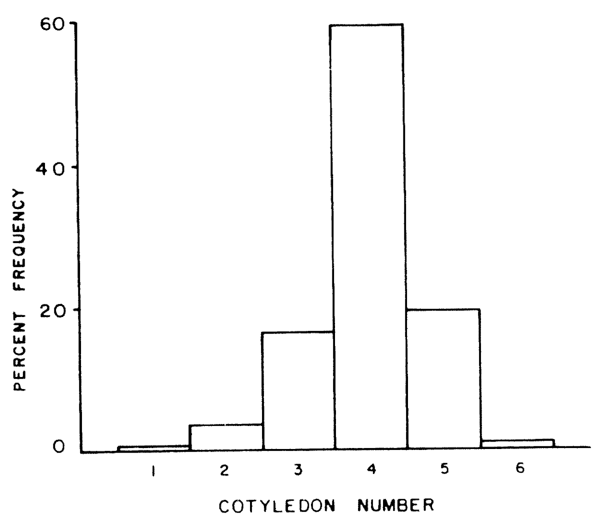

Fig. 2. Percent frequency distribution of *Cola acuminata* nuts on cotyledon number basis.

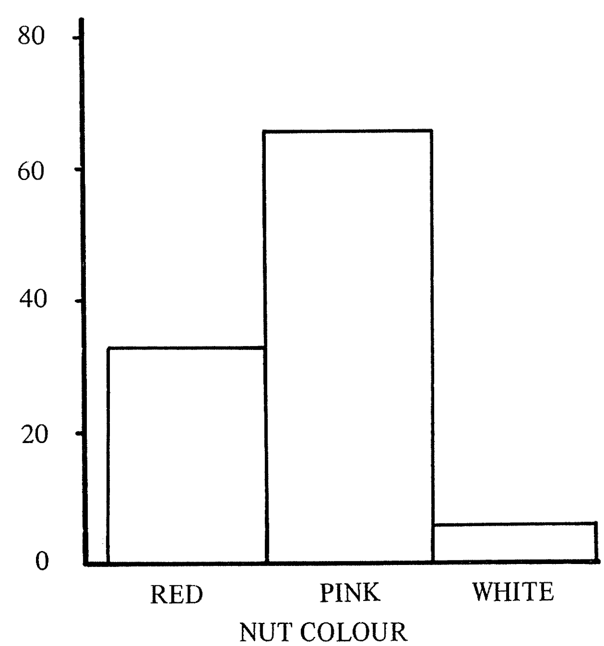

Fig. 3. Percent frequency distribution of *Cola acuminata* nuts on nut colour basis.

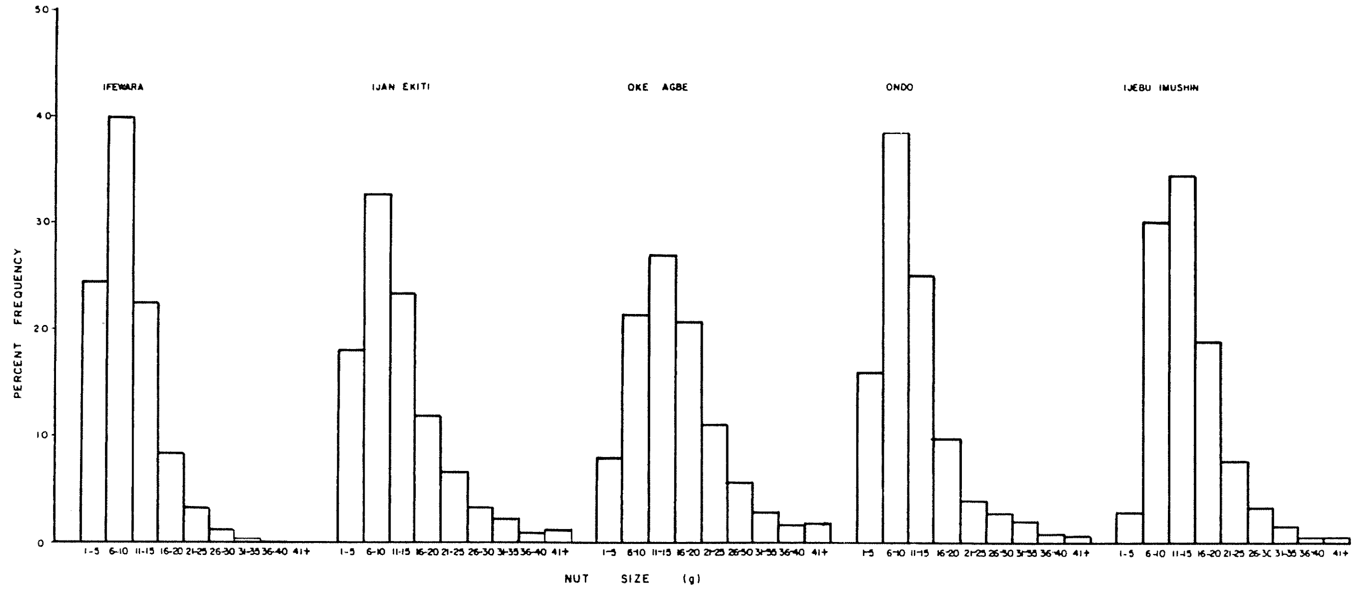

Fig. 4. Variation of *Cola acuminata* nut weight distribution with location.

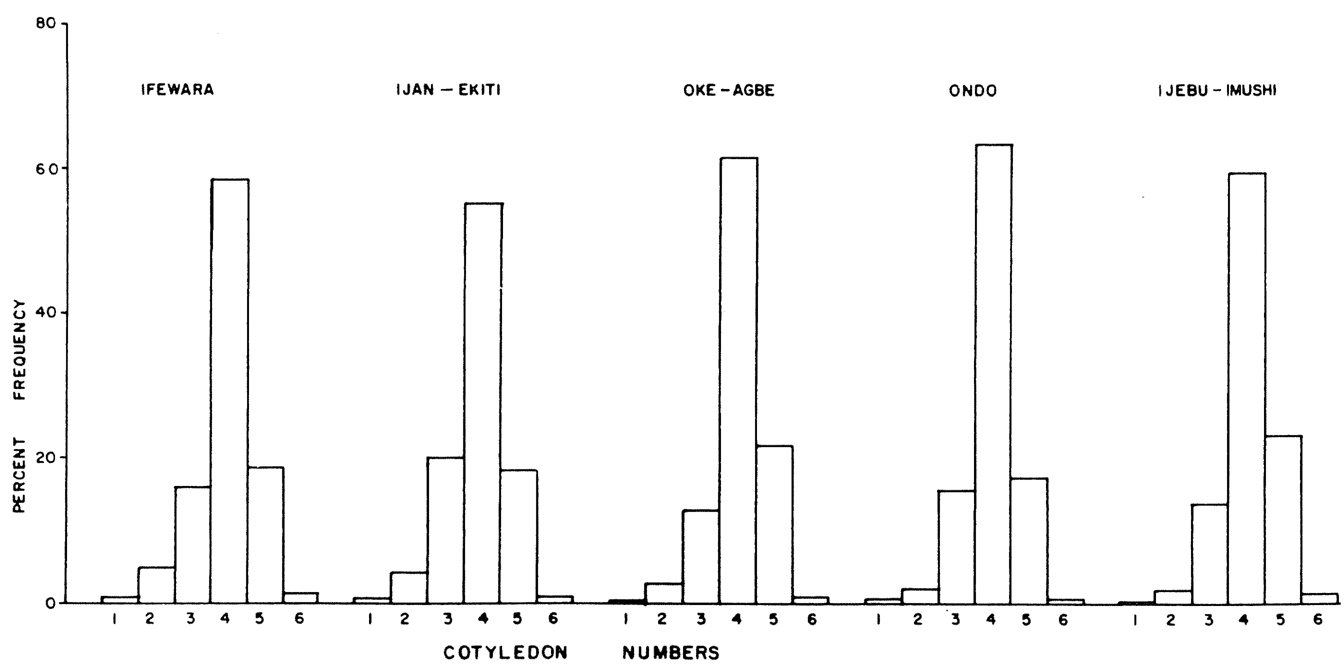

Fig. 5. Variation of *Cola acuminata* cotyledon number distribution with location.

in *C. acuminata* in Nigeria. It is noteworthy to discover that pink nuts were in the majority followed by the red. White nuts convincingly were in the minority. Eijnatten (3) writing on *C. nitida* stated that white nut is recessive to the red nut, while the latter is recessive to the pink nut. On the basis of the results produced above, it is probable the same thing applied to *C. acuminata.* Oladokun (7) found that pink nuts recorded the best germination performance in terms of percentage emergence and velocity. Red nuts came second while the white nuts came last. Thus the influence of genetic colour dominance is manifested in germination ability and is thus understandably manifested in natural selection processes.

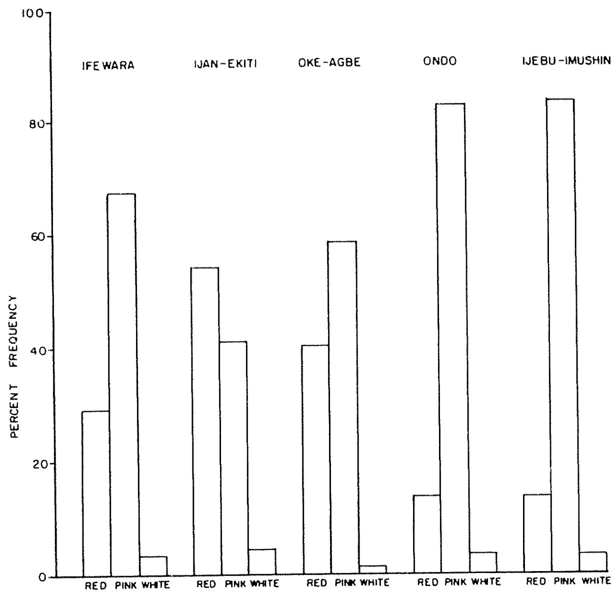

Fig. 6. Variation of *Cola acuminata* nut colour distribution with location.

Conclusions

Nut size, nut cotyledon number and colour are important and distinct characteristics of *C. acuminata.* The variability of these characteristics and the significant interactions among them show them to be a considerable source of breeding and selection programme. White *C. acuminata* nuts are highly preferred to other colours. Breeding for the colour will need to take into consideration its linkage with slow rate of germination as well as nut cotyledon number.

Table 1. Analysis of variance on the arcsin transformed data of nut size, nut cotyledon number and nut colour variation in *Cola acuminata.*

Sources of variation	D. F.	S. S.	M. S.	F.	SIG. LEVEL
Nut size (S)	8	2 296.00	287.000	313.51	* * *
Nut cotyledon number (N)	5	3 176.147	635.229	693.91	* * *
Nut Colour (C)	2	1 376.280	688.140	751.71	* * *
Location (L)	4	29.843	7.461	8.15	* * *
S X N Interaction	40	1 284.907	32.123	35.09	* * *
S X C Interaction	16	434.893	27.181	29.69	* * *
S X L Interaction	32	242.671	7.583	8.28	* * *
N X C Interaction	10	930.325	9.303	10.16	* * *
N X L Interaction	20	64.818	3.241	3.54	* * *
C X L Interaction	8	244.296	30.537	33.36	* * *
S X N X C Interaction	80	317.352	3.967	4.33	* * *
S X N X L Interaction	160	182.525	1.141	1.25	* * *
S X C X L Interaction	64	236.322	3.692	4.03	* * *
N X C X L Interaction	40	235.196	5.880	6.42	* * *
Residual (SXNXCXL)	320	292.939	0.915	–	
TOTAL	809	11 344.514	–	–	

*** Significant at 0.1%.

** Significant at 1.0%.

* Significant at 5.0%.

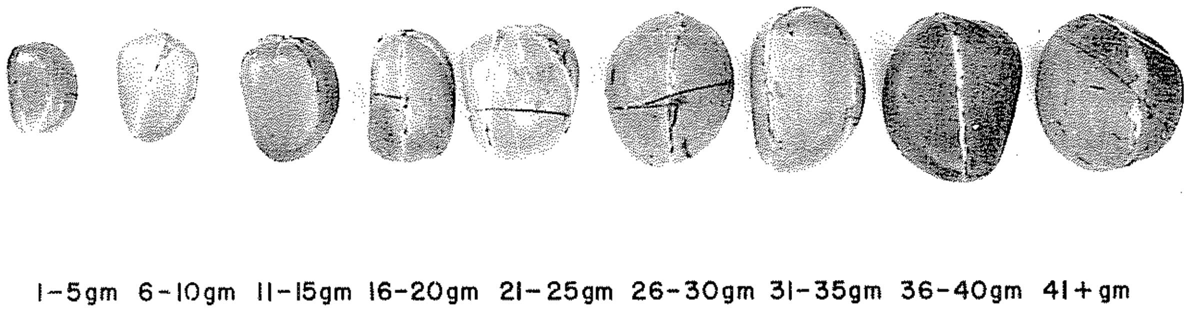

Fig. 7 Nut size variation in *Cola acuminata*

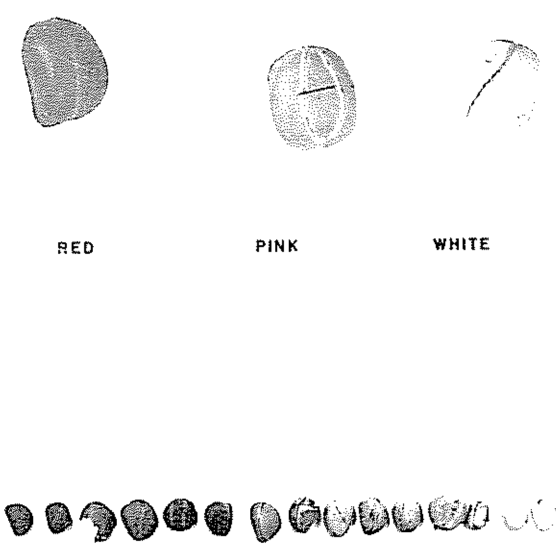

Fig. 8 Nut colour variation in *Cola acuminata*

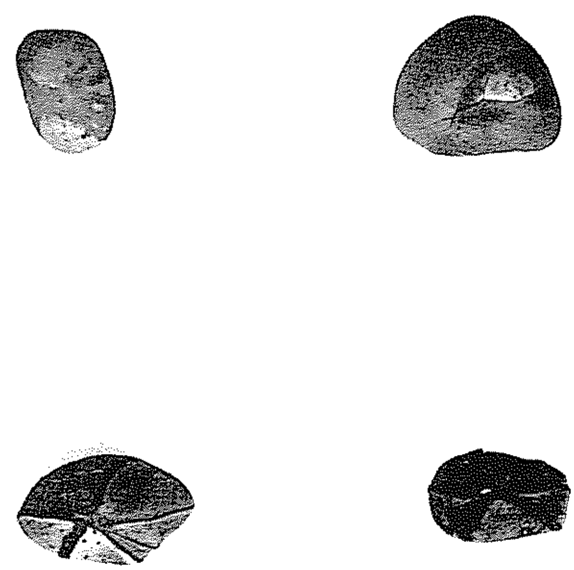

Fig. 9 One –and seven– cotyledon nuts

Abstract

29.428 nuts of *Cola acuminata* obtained from fresh pods collected from Oyo, Ogun and Ondo States were sorted out on the bases of size, cotyledon number and colour. The most common size class was that of 6 – 10 g, followed by 11 – 15 g size class. The most frequent cotyledon number irrespective of size of colour, was four followed by nuts with five cotyledons. Report is made of one and seven cotyledon nuts. Pink nuts were the most frequent, followed by the red. White nuts were relatively few with about 4% frequency.

Statistical analysis showed a 0.1% significant difference for size, cotyledon number, colour and location and the interactions among them were also highly significant (P = 0.001). The importance of the above characters and the use of their variability in future selection work on *Cola acuminata* is discussed.

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Notas y comentarios

Publicaciones

El Servicio de Conservación de Suelos de los Estados Unidos de Norteamérica ha creado el Programa Internacional de Suelos bajo la dirección del Dr. Hari Eswaran. Este programa mantiene correspondencia con personas interesadas en mantenerse al día en la Taxonomía de Suelos a través del National Soil Taxonomy Handbook. Los interesados en este tipo de información pueden dirigirse al Dr. Hari Eswaran National Coordinator International Soil Program. P. O. Box 2890. Washington, D. C. 20013 USA.

EFECTO DE LOS AFIDOS *Metopolophium dirhodum* (Walk.), *Rhopalosiphum padi* (L.) Y *Sitobion avenae* (Fab.) EN LA COMPOSICION QUIMICA RADICAL Y FOLIAR DEL TRIGO[1] /

*ROBERTO CARRILLO LL.**
*VICTOR KRAMM M***

Summary

The effect of aviruliferous aphids M. dirhodum, R. padi *and* S. avenae *on the chemical composition of root and aerial parts was tested on* Triticum aestivum *L. cv. "Express" sown in pots.*

Wheat plants were infested with first instar aphids in numbers of three, ten and thirty by axis, at the stages 2-3, 5-6 and 8-9 Feekes scale respectively. The aphids were killed when the plants were at stages 10.1 to 10.5 of scale.

Aphids affected significantly the total quantity of P and Na present in the root. R. padi *in addition affected significantly the quantity of P in the aerial parts, but the other species did not. The total and relative quantity of N, Ca, K and Mg and the relative quantity of Na and P in both parts was not affected significantly.*

Introducción

Debido a que se ha determinado que algunas de las especies de áfidos que infestan cereales afectan el desarrollo de las plantas de trigo, tanto en la parte aérea (3, 7) como radicular (6), se realizó una investigación con el fin de conocer el efecto que esta acción pueda tener en la composición química foliar y radicular del trigo.

Materiales y métodos

Se empleó trigo de primavera cv. 'Express' sembrado en macetas. Las características químicas del suelo empleado se presentan en el Cuadro 1. Los restantes detalles del material y método empleado se describen en un anterior artículo de los autores (4). La temperatura media diaria durante el ensayo, fue de 16.76 ± 1.14°C y la humedad relativa media diaria de 76.35 ± 8.04%.

El análisis químico de las raíces y de la parte aérea en relación al N, se efectuó mediante el método de Kjeldahl y los minerales Ca, P, K, Na y Mg, mediante absorción atómica vía seca (2). Con los resultados así obtenidos se determinó la cantidad relativa y total de cada uno de los elementos analizados en la planta.

Los resultados obtenidos se sometieron a Andeva y a la Prueba de Rango Múltiple de Duncan.

Resultados y discusión

Las cantidades relativas de los elementos estudiados (Cuadros 2 y 3), tanto en la parte foliar como radicular, no mostraron diferencias estadísticamente significativas, con la excepción del fósforo foliar en el tratamiento con *R. padi,* para lo cual no es posible a los autores una explicación. Sin embargo, tanto este

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Cuadro 1. Características químicas del suelo (Horizonte superficial 0-20 cm).

pH 1:2.5 (agua)	5.35
%C. org. (Walkley y Black)	10.68
%M.O. (%C. x 1.725)	18.40
CIC meq/100 g	41.11
K Int. meq/100 g	1,27
Na Int. meq/100 g	1.19
Ca Int. meq/100 g	4.67
Mg Int. meq/100 g	2.33
%Sat. de Bases	23.01
P aprov. (Hidroxiquinolina) ppm	28.30
%N total (Kjeldahl)	0.78
Relación C/N	13.69:1

tratamiento como *S. avenae* muestran un contenido de P radicular más bajo que el testigo y *M. dirhodum*; estas diferencias no fueron estadísticamente significativas.

En relación a las cantidades de elementos totales en la planta no se determinaron diferencias estadísticamente significativas en el follaje (Cuadro 3). En la raíz de la planta, en cambio, se determinaron diferencias estadísticamente significativas en relación a P, Mg y Na, con respecto a los dos elementos primeramente nombrados. Esto puede deberse a la escasa movilidad de estos elementos en suelo de trumao, especialmente el P, por lo que al reducir los áfidos significativamente la masa radicular de la planta existió una menor absorción radicular de estos elementos. Sin embargo, no es posible dar una satisfactoria explicación en relación al menor contenido de Na, ya que este elemento es altamente soluble.

Los resultados obtenidos para la cantidad total de N, P y K en las raíces de trigo concuerda con lo señalado por Andrews y Neumann (1) y Neumann y Andrews (5) respecto a la absorción de estos elementos. En relación al N, estos autores indican que una baja masa radicular en trigo no afecta la cantidad de nitrógeno en éstas. Con respecto al P, señalan que plantas con una menor masa radicular, lo cual ocurrió efectivamente en este ensayo, presentan una disminución en la absorción y contenido de P en las raíces. En cuanto al K, las plantas con menor masa radicular tienen una mayor absorción de este elemento; según estos autores, en el ensayo ocurrió algo similar (Cuadro 2), ya que las plantas con menor masa radicular tendieron a presentar una menor cantidad relativa de K.

Resumen

Para determinar el efecto de áfidos aviruliferos de las especies *M. dirhodum*, *R. padi* y *S. avenae* en la composición química de la parte aérea y radicular del trigo, se utilizó el cv. 'Express', sembrado en macetas.

Las plantas fueron infestadas con áfidos del primer estadio, en número de tres, diez y treinta por eje, en los estados 2-3, 5-6 y 8-9 de la Escala de Feekes, respectivamente. Los áfidos se eliminaron cuando

Cuadro 2. Efecto de los áfidos *M. dirhodum*, *R. padi* y *S. avenae* sobre la composición química radicular del trigo.

	TRATAMIENTOS			
	M. dirhodum	*R. padi*	*S. avenae*	Testigo
Peso seco raíces (g)	1.239 b	1.258 b	1.305 b	1.737 a
Cantidad relativa de N	1.580 a	1.619 a	1.536 a	1.526 a
Cantidad relativa de Ca	0.228 a	0.135 a	0.155 a	0.170 a
Cantidad relativa de P	0.675 a	0.605 a	0.595 a	0.793 a
Cantidad relativa de K	0.453 a	0.448 a	0.395 a	0.368 a
Cantidad relativa de Na	0.640 a	0.648 a	0.625 a	0.640 a
Cantidad relativa de Mg	0.140 a	0.135 a	0.140 a	0.143 a
Cantidad total de N	0.941 a	2.034 a	1.995 a	2.639 a
Cantidad total de Ca	0.294 a	0.162 a	0.194 a	0.278 a
Cantidad total de P	0.830 b	0.773 b	0.734 b	1.401 a
Cantidad total de K	0.552 a	0.561 a	0.510 a	0.634 a
Cantidad total de Na	0.788 b	0.811 b	0.816 b	1.094 a
Cantidad total de Mg	0.183 ab	0.167 b	0.179 ab	0.242 a

Los valores de cada línea horizontal con distinta letra difieren significativamente a la Prueba de Rango Múltiple de Duncan ($P \leq 0.05$).

Cuadro 3. Efecto de los áfidos *M dirhodum, R. padi* y *S. avenae* sobre la composición química foliar del trigo.

	Tratamientos			
	M. dirhodum	*R. padi*	*S. avenae*	Testigo
Peso seco de la parte aérea (g)	2.28 [a]	2.53 [a]	2.60 [a]	2.59 [a]
Cantidad relativa de N	3 097[a]	2.982[a]	3.214[a]	3 163[a]
Cantidad relativa de Ca	0.455[a]	0.428[a]	0.470[a]	0.410[a]
Cantidad relativa de P	0.550[a]	0.438 [c]	0.475 [bc]	0.498[ab]
Cantidad relativa de K	0.388[a]	0.373[a]	0.390[a]	0 400[a]
Cantidad relativa de Na	0.538[a]	0.528[a]	0.580[a]	0.505[a]
Cantidad relativa de Mg	0.170[a]	0.165[a]	0.173[a]	0.175[a]
Cantidad total de N	7.015[a]	7.532[a]	8.292[a]	8.093[a]
Cantidad total de Ca	1.048[a]	1.039[a]	1.039[a]	1.010[a]
Cantidad total de P	1.218[a]	1.074[a]	1,209[a]	1.269[a]
Cantidad total de K	0 873[a]	0.937[a]	1 006[a]	1.017[a]
Cantidad total de Na	1.220[a]	1.330[a]	1,512[a]	1.294[a]
Cantidad total de Mg	0.389[a]	0.414[a]	0.448[a]	0.446[a]

Los valores de cada línea horizontal con distinta letra difieren significativamente a la Prueba de Rango Múltiple de Duncan ($P \leq 0.05$).

las plantas se encontraban entre los estados 10.1 a 10.5 de la Escala de Feekes.

Los áfidos afectaron significativamente la cantidad total de P y Na presentes en la raíz. *R. padi* fue la única especie que afectó además significativamente la calidad de P presente en la parte foliar.

La cantidad total y relativa de N, Ca, K y Mg y la cantidad relativa de P y Na en ambas partes de la planta, no fue afectada significativamente.

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Reseña de libros

ACADEMIA SINICA, INSTITUTE OF SOIL SCIENCE (eds.). Proceedings of symposium on paddy soils. Science Press, Beijing/Springer Verlag. Hong Kong, 1981. 864 p.

Esta obra incluye 110 trabajos (317 figuras y 445 cuadros) presentados en el "Simposio sobre suelos de arroz anegado", celebrado en Nanjing con la participación de 120 científicos chinos y 56 invitados de otras regiones. El objetivo del documento es el de mejorar el intercambio científico entre los especialistas en suelos de China con los de otros países.

El texto está dividido en tres partes: la primera incluye los trabajos presentados en las sesiones plenarias; la segunda agrupa los documentos de las sesiones de trabajo, y la tercera parte está constituida por las presentaciones en cartelera (*Poster Sessions*). Al final se incluye un apéndice con los trabajos expuestos en la sesión de clausura.

La primera parte es de naturaleza generalista. Las sesiones plenarias fueron destinadas a cubrir asuntos tales como factores edáficos en suelos de baja y alta fertilidad para el cultivo del arroz en China, el manejo y la física de los suelos anegados, la fisicoquímica del sistema oxidación-reducción, problemas de clasificación de suelos anegados, y otros. Esta sección es quizá la que más se acerca al objetivo principal del Simposio, pues las conferencias fueron dictadas por científicos de varias nacionalidades y representantes de diversas instituciones relacionadas con el cultivo del arroz.

La segunda y la tercera parte son trabajos principalmente de China. La segunda parte se subdivide por temas tales como la fisicoquímica del sistema suelo bajo condiciones de arroz anegado, la génesis y clasificación de suelos anegados, y los problemas del manejo de suelos anegados (principalmente relacionados con la fertilización). La tercera parte del libro es muy heterogénea en contenido, aunque la mayoría de los trabajos es de mucho interés.

En el texto se incluye algunos conceptos interesantes y novedosos; en la clasificación genética de suelos anegados en China (p. 134) se habla de horizontes "submergénicos" (oxidados), "percogénicos" (redox) y "subhidrogénicos" (reducidos), los cuales se agrupan bajo la denominación de horizontes W y se forman por translocación de hierro y manganeso sin movimiento de aluminio. Otro término interesante es el "comportamiento fisiológico del suelo" (p. 389), empleado para denotar las propiedades inherentes del suelo, que cambian con el tiempo bajo la acción conjunta de los factores ambientales, tales como cambios diurnos o estacionales del clima, los procesos fisiológicos que ocurren en las plantas y las actividades humanas.

El documento es interesante por cuanto resume el conocimiento existente sobre estos suelos hasta 1980, pero además permite conocer el avance de la ciencia en este campo en China. Desde el punto de vista editorial cabe mencionar un sinnúmero de errores de ortografía, los cuales son comprensibles si se piensa en la magnitud del esfuerzo de traducción realizado por la Academia Sínica.

La obra es básica para quienes laboran con el cultivo de arroz, así como para especialistas en la ciencia del suelo interesados en suelos anegados.

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CROPPING SYSTEMS AND SOIL CONSERVATION IN THE HILL AREAS OF TROPICAL AMERICA[1] /

JOSHUA L. POSNER*

Resumen

La mayoria de los alimentos básicos en la América Tropical se producen en fincas pequeñas ubicadas en zonas de ladera. Un análisis de los sistemas agricolas actuales y del pasado en esta región, indica que en la conversión del agua y del suelo influyen varios elementos, las que en conjunto promueven su estabilidad. Se sugiere que los encargados en investigación en el campo agricola deberian enfocar sus esfuerzos hacia los sistemas de agricultura de ladera para mejorar su productividad en términos sostenidos.

Introduction

The hill areas of tropical America are characterized by small holdings, steep slopes, annual cropping and poverty. This combination of factors has created serious problems of soil erosion causing land degradation in the hills and flooding and silting in the lowlands. There has been a tendency for planners and agronomists alike to emphasize the negative aspects of hillside farming and to encourage alternative land use patterns. As a result they ignore many of the soil conserving components of present farming systems.

This paper will review some of the environmental constraints and the strategies employed by traditional farmers to modify these constraints for agricultural production on steep slopes. Careful consideration of these soil and water conservation strategies should help to improve the productivity and sustainability of on-going agricultural production programs.

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Current importance of the hill areas

A combination of geographic, climatic and historical forces has resulted in great population concentrations in the highlands of Mexico, Central America and the Andean countries. Table 1 gives estimates of the total area, arable land, the percentage of the national population, and agricultural population on the steep slopes. Posner and McPherson (49) suggest that from one-third to one-half of the farmers and from 20 to 40 percent of the arable land are on steep slopes. The major use of this arable land is for food crops and recent estimates show that 40 to 80 percent of national food crop production comes from hill farms (49, 60, 67).

Historical perspective

Historically the hill areas of tropical America were used for food production. They had numerous advantages for the aboriginal farmer. The steeply sloping areas were easy to clear since they were usually in forest and with an axe and fire the land could be made ready for planting. In contrast, the flat areas often had poor drainage and were covered with dense grasses, a difficult type of vegetation to control without animal traction (64). Also, burning on slopes was easier than on flat lands in that the updraft

Table 1. Estimated area, arable land[a] and population on steep slopes[b] of Tropical America[c].

Country	Percent of National Area	Percent of Arable Land	Percent of National Population	Percent of Agricultural Population
(1)	(2)	(3)	(4)	(5)
Mexico	45	20	15	45
Guatemala	75	30	40	65
El Salvador	75	40	30	50
Honduras	80	15	15	20
Costa Rica	70	25	20	30
Panama	80	10	15	30
Jamaica	60	50	15	30
Haiti	80	70	50	65
Dominican Rep.	80	15	15	30
Colombia	40	25	15	50
Ecuador	65	25	25	40
Peru	50	25	25	50

a Arable land includes only the land used for annual crops. It refers to cropped and/or fallow land which is part of the normal rotation. Thus, arable land includes all the land in sugar cane, cotton, and other annual crops, but excludes perennial crops such as coffee and bananas and permanent pasture lands.

b Steep slopes – slopes above 8 percent, intermontane valleys and highland plateaus.

c The data in this table are tentative. They are based on USAID, FAO and World Bank sources, discussions with a number of scientists, and personal estimates.

Source: Posner and McPherson (48) Table 1.

caused hotter burns and the fire was more easily controlled since it rarely would burn downhill (6). A further advantage of the slopes at high elevations was less danger of frosts due to better air circulation. On slopes with deep but poor soils the gradual erosion of the exhausted topsoil exposed more fertile subsoil permitting annual cropping (17, 47).

These advantages were offset by the problems of generally thinner topsoils and the greater risk of drought damage due to increased water runoff. According to Donkin (20), farmers responded to this problem by terracing, since these structures increased the depth of topsoil and reduced surface runoff. He found that 85 percent of the terraces discovered in the Americas are in areas with less than 900 mm of rainfall and have five or more dry months. Rather than out of concern with soil erosion, according to his thesis early Indian farmers terraced to increase soil moisture holding capacity and to permit irrigation.

In fact, Spores (55) suggests that the farmers of the Mixtec culture actually tried to promote erosion for the purpose of accumulating the soil as alluvial deposits behind check-dams. This "lama-bordo" terrace system which was formed with soil collected in this manner was the basis of agricultural production prior to the arrival of the Spanish. Wright (69) provides a similar example from the desert Pacific coast of Chile where erosion promoted agricultural development. He speculates that silt trapping by building check-dams transformed nomads into agriculturalists since it provided a technique of deepening soils near sweet water supplies. He further suggests that in the lowland humid tropics, where soil fertility, not moisture is the main limiting factor, terraces were unnecessary. Long rotations or erosion itself were the two simplest ways to renew soil fertility. The major exception to this generalization is in the Mayan areas of the Yucatan Penninsula where thin but fertile limestone soils were terraced with check-dams in order to deepen them (59).

Before the arrival of the Spanish, both the Inca (40) and Aztec (18) Empires were suffering from the effects of serious soil erosion. Most researchers also suggest that the collapse of the Mayan Empire some 500 years earlier had also been caused by reduced productivity due, in part, to soil erosion (19, 43). With the Conquest in the first half of the 16th Century came the "population catastrophe," significantly reducing population pressure on the land. As reported by Eckholm (22), demographers estimate that the Indian population was reduced by as much as 75 percent during the first century of colonial rule due to diseases, forced labor and warfare. Demographers estimate that the rural population in Mexico, Guatemala and the Andean countries did not again reach 1500 levels until after 1950 (61). Since that time, population has expanded rapidly, as have the urban centers, resulting in severely increased pressure on the hills for food production. A fundamental question for planners and agronomists alike is whether or not the steeply sloping areas can continue to produce the bulk of the food crops or, as has happened before, will these areas "collapse" due to erosion and overpopulation?

Global estimates of soil loss and erosion plot measurements

Numerous researchers have attempted to estimate the area severely affected by erosion [at least 75 percent of the topsoil has been lost and numerous deep gullies exist (7)] in tropical America. A selected list of these evaluations is presented in Table 2. In the Caribbean countries over 50 percent of the land suffers from severe erosion while in the Andes the estimates are higher. Even in areas that are predominantly flat such as Cuba or the Savannah of Bogota, estimates indicate that large areas are affected by erosion. While there is no doubt that erosion exists, these estimates are so general and so high that they are difficult to place in perspective. As such they have most often hindered constructive thinking about the erosion problem and persuaded government policymakers that their hill areas will soon be denuded and abandoned.

In contrast to these general estimates, close examination of experimental data from erosion plots (Table 3) have two striking features: there is a wide range in the rates of soil loss; and a large number of soil management systems have sustainable soil losses. Tosi (58) estimates that the soil loss tolerance on deep soils of the humid lowland tropics may be from 25 to 40 ton/ha/yr. This is equivalent to approximately 2 to 4 mm of topsoil a year.

Nevertheless, some cropping systems are incredibly destructive. For example, Sheng and Michaelsen (52) show that monocropped yam cultivation in Jamaica

Table 2. Global estimates of damage due to erosion.

1. 42 percent of Mexico suffers from accelerated erosion.
   Conservation Foundation in Baldwin (7).
2. 77 percent of El Salvador suffers from accelerated erosion.
   Organization of American States (1969) in Eckholm (23).
3. 30 percent of the Savannah of Bogota in Colombia has severe erosion.
   CEPAL (16).
4. 75 percent of the land between Loja and Cuenca in Ecuador has been abandoned due to severe erosion
   Giroux in Portch (48).
5. 83 percent of the Peruvian Andes loses more than 10 ton/ha/yr of topsoil
   Low (38).
6. 50 percent of the cropland in the Dominican Republic is on steep slopes and suffers from accelerated erosion.
   Organization of American States (1969) in Ahmed (2).
7. 60 percent of the cropland in Jamaica is on steep slopes and suffers from erosion
   Wilson (67).
8. 25 percent of the declared agricultural land in Jamaica was incapable of reforestation or renewed agricultural use
   Blume (12).
9. 80 percent of Cuba suffers from serious erosion.
   Saouma Dir. Gen. of FAO in Gamma. Sept. 14, 1980.

Table 3. Summary of runoff plot measurements of erosion in Tropical America.

Location	Slope	Cover	Erosion (ton/ha/yr)	Reference
Humid Tropics				
Trinidad	25	Corn relay cowpea	3	Lindsey (37)
Trinidad	35	Pineapple on terraces	5[a]	Alleyne & Percy (4)
Puerto Rico (Mayaguez)	40-45	Annual Crops	44	Smith & Abruna (54)
		Sugarcane-burned	19	
		Sugarcane – with mulch	2	
		Pasture	5	
Jamaica (Smithfield)	30	Yams-traditional culture	134	Sheng and Michaelsen (52)
		Yams with contour mounds	27	
		Yams on terraces	17	
Peru (San Ramon)	30	Potato-fallow-potato	16	Felipe-Morales (28)
		Corn-beans-potato	119	Felipe-Morales (27)
Wet-dry Tropics				
El Salvador	30	Corn relay beans	100	Sheng (53)
		Corn relay beans on terraces	30	
High Elevation Tropics				
Costa Rica (Turrialba)	45	Annual crops	0	Ives (35)
Colombia (Chinchina)	22	Pasture	7.1	Suárez de Castro (56)
	45	Young coffee trees	1.8	
Panama (Boquete)	35	Carrots and beans	80	Oster (44)
Peru (Huancayo)	25	Potato-fallow	5	Felipe-Morales (28)

a Total soil loss per ha during 18 storms.

led to an average soil loss of 133 ton/ha/yr. Blaut (11) observed that Jamaican farmers did not attribute any of the plant nutrition to the minerals in the soil, but rather to the "juices" in the rotting fallow grasses of the previous cycle. As a result, sheet erosion is not a concern to many traditional farmers. Similar losses have been reported for potato production in the eastern Andes of Peru. In this case, a burnt fallow, on a 30 percent slope, was followed by clean cultivated corn, then beans and finally potatoes, and soil losses measured 119 ton/ha/yr (27). The previous year, however, with 25 percent less rainfall, a rotation of potato-fallow and burning-potato resulted in a moderate soil loss of 16 tons/ha/yr (28).

At higher elevations, with the exception of the work with vegetables at Boquete, Panama (44), soil loss measurements are much lower than in the lowland tropics. Under these cooler conditions Tosi (58) estimates soil loss tolerances of twelve to twenty ton/ha/yr so most of the systems reported in Table 3 would be sustainable.

Universal soil loss equation

To understand why some systems are relatively stable, even on steep slopes, it is useful to consider the Universal Soil Loss Equation of Wischmier and Smith (68):

$$A = RKLSCP$$

This identity states that soil loss (ton/ha/yr) (A) is a function of rainfall erosivity (R), soil erodability (K), slope length (L), percent slope (S), crop cover (C), and soil conservation practices or structures (P).

Environmental factors

There is a wide concensus that in the tropics, rainfall is the most important factor in promoting erosion (30, 36, 51). Table 4 lists some of the rainfall erosivity (R) measurements from the literature. As can be seen, the humid tropics have very intense rainfall activity (8, 45), as do the wet-dry tropics (56). In contrast, the storm intensities and duration are often much less at higher elevations, which is reflected in the lower "R" values. For example, measurements made in Turrialba, Costa Rica (5), Huancayo, Peru (21) and Quito, Ecuador (29) indicate that average rainfall erosivity is less than one-tenth of that on the windward side of Jamaica.

In addition to the variations in the erosivity of the climate between locations in tropical America (total R), rainfall distribution is also an important factor in soil erosion. For instance, the R-factor is uniformly distributed by month in a location like Turrialba (Table 5), while in both Jamaica and the Dominican Republic the months of June and September or October experience intense rainfall. Depending on soil cover during these months, serious erosion may or may not occur. This aspect of rainfall distribution has important implications for timing and type of soil preparation, as well as mixed and relay cropping.

Surface soil structure is measured as the K-factor. As can be seen in Table 6, tropical soils tend to be several times more stable than temperate climate soils due to the better aggregation and infiltration rates associated with oxisols, ultisols and andisols.

Table 4. Annual rainfall erosivity (R) in selected locations of Tropical America[a].

Location	R (metric)	Reference
Humid Tropics		
Jamaica – Smithfield	2603	Hutchingson and Forsythe (33)
Ivory Coast – Abidjan	2192	Roose (51)
Puerto Rico – Mayaguez	1353	Barnett (8)
Dominican Republic – Quemados	1428	Paulet (45)
Peru – Iquitos	2600	Paulet (45)
Wet–Dry Tropics		
El Salvador – San Salvador	1150	Forsythe in S. de Castro (57)
Upper Volta – Ouagadougou	750	Roose (51)
Dominican Republic – Valdesia	1123	Paulet (45)
High Elevation Tropics		
Costa Rica – Turrialba	123	Amezquita and Forsythe (5)
Ecuador – Quito	224	Flores (29)
Peru – Huancayo	100–200	Paulet (45)
Temperate Zone		
USA – Illinois	350	Wischmeier and Smith (68)
USA – Gulf Coast	950	Wischmeier and Smith (68)
Central France	100–600	Roose (51)

a Rainfall erosivity index is the product of the total storm kinetic energy times the maximum 30 minute intensity. The annual index is the sum of the R values calculated for each rainstorm during the year.

Table 5. Monthly distribution of rainfall erosivity (R) in three locations of Tropical America.

Date	Location		
	Turrialba	Smithfield	Valdesia
(1)	(2)	(3)	(4)
		(percent)	
January	4.1	2.4	1.1
February	4.6	5.1	0.3
March	1.6	5.2	1.1
April	6.3	3.9	5.8
May	7.1	8.8	8.4
June	11.5	17.0	18.1
July	11.0	10.4	8.4
August	10.7	7.9	14.2
September	11.2	9.0	28.3
October	9.8	21.4	11.0
November	9.1	6.5	2.1
December	13.0	2.4	0.9
Total R metric	122	2600	1123.3
rainfall mm	2680	2500	1124

Source: Col. 2: Amezquita and Forsythe (5)
Col. 3: Paulet (46)
Col. 4: Paulet (45)

Table 6. Soil erodibility indexes (K) in selected tropical locations.

Location	Soil Type	K metric	Reference
USA – Hawaii	Humoxic Tropohumult	0.13	El–Swaify and Dangler (24)
	Typic Torrox	0.31	El–Swaify and Dangler (24)
	Tropeptic Eutrustox	0.22	El–Swaify and Dangler (24)
USA – Puerto Rico	Typic Tropohumult	0.01	Barnett (8)
	Vertic Eutropepts	0.02	Barnett (8)
	Typic Dystropepts	0.115	Barnett (8)
Trinidad	Orthoxic Tropudult	0.12	Lindsay (37)
	Orthoxic Tropudult	0.08	Lindsay (37)
Costa Rica – Turrialba	Alluvial	0.155	Amezquita y Forsythe (5)
	Typic Dystropept	0.103	
Ecuador – Quito	Entic Dystrandept	0.18	Flores (29)
USA – New York	Dunkirk Silt loam	0.89	Wischmeier and Smith (68)
USA – Ohio	Keene Silt loam	0.62	Wischmeier and Smith (68)
USA – Texas	Boswell fine sandy loam	0.32	Wischmeier and Smith (68)

However it would be a mistake to assume, based on Table 6, that all tropical soils are stable. The erodibility analysis (K) is only conducted on the topsoil, and often the B horizon, if it is relatively impermeable, is a more important determinant of the potential for soil erosion (1, 2, 30). Barnett's (9) work in Puerto Rico showed that 90 percent of water that infiltrated the plow layer on a Juncos silty clay soil reappeared at the end of the plots, as interflow, and not surface runoff. This interflow can cause landslides or soil slumping as it lessens the friction along the interface of the impermeable subsoil and permeable topsoil. Also the "K" indexes are based on the stability of initially dry soils. According to El-Swaify (25), with soil high in amorphous aluminum oxides (volcanic soils), previous moisture condition is important in measuring their stability in any given storm, and often the K values are under-estimated under experimental conditions.

The two main characteristics of the slope itself are "L" and "S:" slope length and percent slope. Although not mentioned in the equation, hill aspect is important and erosion problems on the leeward and windward sides of a slope are different. Simple geometry shows that a slope will receive less rainfall than adjacent flatlands if the rainfall is falling vertically. If the wind is blowing the rain away from the slope (leeward aspect) then rainfall will be much less than on the flatlands. In addition to moisture effects, slope direction and therefore wind impact can markedly increase the actual erosivity of the rainfall (1).

Farming system factors

The remaining two factors in the Universal Soil Loss Equation, crop cover (C) and soil conservation practices (P), are under the farmers' direct control. Traditional soil conservation practices include: mixed cropping and relay cropping, which improve the effectiveness of the crop cover; no-tillage and weeding with only a machete, which leaves a protective mulch on the soil; terracing, bunding and hedge rows, which serve as conservation structures; and rotations, which improve soil stability and take land out of row crops, at least for part of the cycle.

The key component of the traditional hillside soil conservation strategy is the maintenance of good vegetative cover of the soil. While often low soil fertility or potential drought stress precludes the use of high plant populations, most locally adapted varieties have both rapid growth rates and high leaf area indexes which provide protective cover for the soil. Also, rapid canopy development is usually a prerequisite for high yields, so conservation and productivity are complementary.

Hudson (32), in an experiment which demonstrated the importance of crop cover, reduced erosion from bare soil on 4.5 percent slope by over 99 percent by simply covering the plot with thin mesh wire gauze. Barnett (9), in Puerto Rico, further demonstrated the importance of the canopy as an interceptor of the kinetic energy of rainfall by clipping at soil level a grass plot (*Digitaria decumbens*). This treatment resulted in a tenfold increase in soil loss when compared with the check plot that had not been cut. In addition to the binding effect of the roots, the check plot also had leaves protecting the soil from direct rainfall.

In annual cropping areas a major soil conservation strategy is the use of rotations which not only serve to reduce the incidence of certain soil borne pests and rejuvenate fertility, but also protect the land while it is fallow. Personal estimates made in Turrialba, Costa Rica, and the coffee zone of Colombia indicate that as much as 80 percent of the land at any one time is in pasture, tree crops and sugarcane. In the annual crop producing zone of Huancayo, Peru, Werge (63) estimated that only 10 percent of the land is in crops at any one time. Numerous authors refer to the "laymi" system common in the high Andes where often five years out of seven the land is in fallow (13, 31).

In addition to the grass tops protecting the soil, fallows improve soil structure. In the warmer tropics, Hudson (32) estimates that fallows of only two years build up soil structure sufficiently to permit one year of annual cropping. In his work in southern Africa, he found that grass fallows rapidly created loose aggregates in the topsoil and the resulting organic matter reduced erosion significantly by increasing infiltration rates for one year after the land was plowed up and planted. However, this improved structure rapidly broke down and by the second crop year, erosion had increased threefold over the previous year.

Loose aggregates and large pieces of organic matter result in soils with high initial infiltration rates. This is important in the tropics where peak rainfall intensity often occurs at the beginning of rainstorms. Wilkinson (65) studied 58 storms of 10 mm or more in western Nigeria and found that peak intensities were recorded in the first minute for 26 percent of the storms; first five minutes in 56 percent of the cases and fully 75 percent of the storms within the first 13 minutes of rainfall.

In addition to rotations, which improve soil stability (K) and provides good cover (C), farmers use a number of other strategies that effectively protect their soil. Often hillside fields in the humid tropics are prepared with a minimum of tillage, leaving cut grass or tree trunks on the ground to serve as a type of mulch (39). These fields are then sown with a planting stick which according to Buchele (14), disturbs only approximately 0.04 percent of the soil. In Costa Rica another technique is the system of "frijol tapado" in which the bean seed is broadcast into a fallow field and then the tall grass is simply cut, covering the seed. These activities, in addition to reducing some pest problems, can increased soil organic matter (improve K-values) and of course improve the soil cover (C).

Another approach is to increase the density of crop canopy and the length of time it remains. Mixed cropping is an example of the former where often a slow growing crop is grown with a fast growing crop (cassava and corn) or a tall crop is grown with a short one (corn and squash). Work in Nigeria has shown that cassava cropped with corn on a 10 percent slope resulted in only 70 percent as much soil loss as when grown alone (3).

In more humid areas planting prior to the onset of the rains and using relay cropping are two further traditional means of increasing canopy effectiveness by increasing its duration. The first method creates some ground cover against the force of the beginning rains. The second, planting a prostrate bush bean into the standing corn, for example, can offer good canopy cover for the heavy late rains in areas with a bimodal season (Table 5).

Although a small point, crop canopies on hillsides are more effective in protecting the soil than on flatlands when the rain is falling vertically. Using the data generated by Wilkinson (66), a 1.8 m high corn crop (LAI = 4.9) on a 60 percent slope will permit only one-half as much direct penetration by light or rain as will the same plot on flatland.

Conservation plantings or structures (P) are less common in traditional systems, but one can observe for example grass waterways in Colombia, contour plowing with oxen in Peru and newly constructed "andens" (sloped terraces) in Ecuador. Perhaps the most important traditional conservation structures have been the use of hedge rows and walls as property boundaries. Often these barriers run across the slope and serve to trap eroding soil behind them. From the vantage point of soil conservation, land parcelization may be an advantage.

Generalized farming systems scheme

I have identified four major farming system/erosion control complexes to organize the information above.

I **Wet highlands** (Guatemalan highlands, coffee highlands of Central America, the northern Andes of Colombia and Ecuador). These are areas often with deep volcanic soils and mild precipitation (Table 4). Generally farmers have relied on good crop cover to reduce erosion either through the use of tree crops (coffee, citrus) and grasses (pasture, sugarcane) or with sophisticated relay cropping and mixed cropping methods.

II **Dry highlands** (Central Plateau of Mexico, the central Andes of Peru and Bolivia). As in I, the soils are generally stable, rainfall is mild but it is inadequate, which means that moisture is a major limiting factor in crop production. One solution historically was to increase soil depth and reduce runoff by means of terracing. Whenever possible, terracing was combined with irrigation. Another solution was to go to even higher elevations (cooler climates) where the hydric balance was more favorable to crop production. Here the low erosivity of the rainfall and a long rotation system permitted continual use of the steep, unterraced slopes.

III **Wet lowlands** (Caribbean rim and eastern Andean foothills). These are areas with highly erosive rainfall patterns (Table 4), generally deep stable soils (Table 6) and usually abundant rainfall. A long cycle of slash-and-burn agriculture has predominated in the area until recently, and this system has been successful in maintaining soil fertility (42) and in controlling erosion (26). Where permanent agriculture has been established, farmers often rely on tree crops, mixed cropping and minimum tillage techniques.

IV **"Wet-dry" lowlands** (Pacific Coast of Central America, Caribbean coast of South America, lower Andean valleys). Included among this group are areas with aggressive rainfall, generally stable soils and a well-defined often bimodal rainy season with usually 5 or more months where evaporation exceeds precipitation. Historically, they were not heavily populated but increasing population density has caused the expansion of annual cropping to the steep slopes. The lack of ground cover at the beginning of the rainy season is causing serious erosion. Often the hills are planted in local varieties of corn and sorghum, which provide good canopy cover, at least late in the season. Other areas are in cassava, one of the few crops that can produce under the low fertility equilibrium state that is established between soil losses and pedogenesis.

The above groupings serve both to classify farming systems strategies and to highlight the conditions under which soil erosion is most likely to be severe. Annual cropping in the tropical wet lowlands is risky and as the data from San Ramon (Peru) and Smithfield (Jamaica) show, high soil losses can be expected from monocropped, clean cultivated tuber crops. On the other hand, no-tillage systems and plots with hillside ditches showed a nearly 60 percent reduction in erosion losses in both cases. Also, in the wet-dry topics the combination of steep slopes, erosive rainfall and long dry spells makes this perhaps the area of greatest concern. High value crops have not yet been identified that are well adapted to the steep slopes, so terraces are hard to justify economically. In addition, the long dry season limits the possibilities of no-till planting since little mulch is available as the cropping season begins. Generally the cropping patterns in these areas are simply mining the soil.

At higher elevations, the climate is more benign, and coupled with the intensive local farming patterns, many sustainable systems have evolved. Nevertheless, these are the areas of greatest population growth resulting in shorter rotations and the cultivation of steeper slopes.

A major challenge for agricultural scientists and economic planners will be to design programs to increase food production in the threatened, but important hill lands. Over time, a relatively stable equilibrium was established between the limitations of the environment and the needs of the hill farmers. Some systems, even under increasing population pressure, have remained stable, and almost all hill systems have important elements which serve to check erosion. The current task is to evaluate present patterns and proposed innovations with a conservationist point of view.

Conclusions

Current research and development in the hill areas is often doubly handicapped as research station orientation is toward the flatlands, and hill development is left to soil conservation agents whose approach is regulatory and whose primary focus is on conservation structures. Since most farms and most of the food crops are in areas with erosion problems, crop and livestock researchers should logically focus their attention on the hill environment.

Indeed the majority of agricultural research stations in tropical America are located at low elevations on flat land. For example, the six Central American countries have 32 agricultural research stations (34) while the five Andean Pact countries have 63 (10). Few of these stations include steep sloping land where field experiments can be conducted to study cropping systems under varying soil and water conservation practices. There is also a low elevation bias in the location of these stations. In the Andean countries, over three-quarters of the stations are at elevations of less than 2 500 meters. In Central America, where elevation bias is less pronounced, the research emphasis of genetics and plant improvement (65 percent of the effort) dominates. The attention given to the concerns of the small farmer on steep slopes, namely weed control, irrigation, and soil conservation is minimal (3 percent of the effort).

Agronomists and breeders need to evaluate their development programs in terms of crop cover and intercepting rainfall. Either through increasing crop cover duration or intensifying the cover itself, improved farm systems can both increase yields and reduce soil losses.

Foresters and pasture researchers can help to convert the marginal slope cropping areas into more stable mixed systems with agroforestry or grass ley rotations. Most of the densely settled hill areas have both a firewood and forage shortage, so tree species for firewood and short grass rotations benefiting the soil and their livestock would fit into the current farming systems.

Experience with terracing throughout tropical America, certainly an important option on steep slopes, indicates that only if the structures are combined with new inputs (notably fertilizer) or new high value crops (eg., vegetables) can they become a permanent part of the farming system (15, 41). This requirement for immediate payoff with terracing further highlights the need to include agricultural research with the civil engineering task of terrace construction as, for example, is being done in northern Honduras (50) and in Jamaica (62).

While soil conservation is not the primary concern of farmers, it should be considered and evaluated in the generation of new technology. Hudson (32), in work completed in the late '50's, developed an index comparing kilos of yield with kilos of soil loss and found that the high input corn crop produced ten times as much grain per kilo of soil lost as his low input crop. Buchele (14) inverted this index in discussing a colleague's work and found that conventional tillage corn lost five times as much soil per kilo of grain as did no-till corn on a 9 percent slope. It would be useful if farming systems agronomists in Latin America gained this perspective as they work on small farmer production systems – i.e. those which are predominantly adapted to the steep sloped areas.

Summary

Most of the basic food crops in tropical America are grown on small hill farms. An analysis of the tropical environment and present and past farming systems indicates that there are many elements which help to conserve soil and water, thereby promoting the sustainability of the system. It is argued that agricultural researchers should focus on current hill farming systems and in addition to improving their productivity, evaluate them for sustainability.

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Reseña de libros

PALTI, J. Cultural practices and infections crop diseases. Berlin, Springer-Verlag Advanced Series in Agricultural Sciences No. 9, 1981. 243 p.

Rara vez se tiene la oportunidad de revisar un libro de fitopatología eminentemente práctico y ubicado dentro de las necesidades actuales, en donde se trata de racionalizar las prácticas culturales tradicionales complementándolas con las investigaciones más recientes acerca del combate integrado de enfermedades. A su vez, para dar una visión general e integral, se hace un enfoque moderno de este control al relacionarlo con los agroecosistemas. En este sentido el libro es excelente como material de enseñanza, ya que muy frecuentemente se transmite al estudiante cantidad de detalles que lo hacen perder esta clase de visión, además de que utiliza con asiduidad figuras y cuadros muy didácticos.

En la primera parte, y con el fin de ubicar al lector, se describen las prácticas de cultivo utilizadas en cada uno de los agroecosistemas y el microclima generado por la topografía, el suelo y el cultivo mismo. Seguidamente se analiza el efecto del manejo del inóculo mediante prácticas culturales en la epidemiología y el combate de enfermedades, enfocado hacia regiones o comunidades de agricultores. También enfatiza en forma concisa y profunda el influjo del suelo y la flora microbiana en la incidencia de enfermedades del suelo. Siempre haciendo énfasis en la integración de conocimientos analiza los factores de *stress* con relación a las enfermedades, principalmente aquellos provocados por alta o baja temperatura y la deficiencia o exceso de agua. La sección de la relación malezas-patógenos se discute con claridad e incluye un cuadro con el ámbito de hospedantes de patógenos comunes en diferentes agroclimas.

En la segunda parte, que es la principal, y siguiendo una secuencia lógica se analiza con sumo detalle y a nivel finca el impacto que tiene cada una de las prácticas culturales en el desarrollo de enfermedades. Comienza por destacarse la importancia que tienen estas prácticas en la relación costo/beneficio para los agricultores, pero considerando no sólo el aspecto económico en la toma de decisiones sino el político y social. Asimismo estudia lo difícil pero importante que es tomar decisiones en el combate de enfermedades cuando se tienen múltiples alternativas de escogencia, aspecto que el autor presenta en forma esquematizada y de fácil comprensión para el lector. Aunque no hay nada nuevo en cuanto a los principios y medidas de combate, se hace un enfoque tan profundo de cada uno de ellos que el lector se encontrará, por ejemplo, con cuadros en los que se presenta aquellas enfermedades en las que se puede reducir el daño con quema de residuos, calentamiento solar, suplencia adecuada de potasio y otros. Especial énfasis se da a las secciones de rotación de cultivos y sus implicaciones económicas, la incorporación de materia orgánica, uso de coberturas, preparación del suelo y buen manejo de la fertilización y el riego.

Para integrar toda esta información, en la tercera parte se analiza las interacciones que ocurren entre el control químico, el control cultural y la resistencia, con el fin sobre todo de reducir el número de aplicaciones de fungicidas utilizando para ello excelentes ejemplos presentados como figuras y esquemas.

El libro está definitivamente enfocado hacia la protección de cultivos en sistemas de explotación tecnificados, haciendo énfasis sobre la planificación de estrategias de combate, más que curar enfermedades, de ahí que destaque la importancia de educar al agricultor en este sentido. Sin embargo, el libro brinda muchas ideas que pueden ser adaptadas a sistemas de explotación poco extensivos y tecnificados, de manera que en este campo es una buena guía para investigadores, sobre todo por la amplia información bibliográfica que posee.

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MORFOLOGIA E ANATOMIA DAS SEMENTES E PLÂNTULAS DE *Eucalyptus intermedia* R. T. BAKER[1] /

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Summary

The morphology and anatomy of the seeds and the early development of Eucalyptus intermedia *R. T. Baker are described emphasizing the structure of the seed coat and embryo, with the purpose of providing the basis for their identification.*

Introdução

Tendo em vista a crescente importância do gênero *Eucalyptus* nos programas de reflorestamento e a necessidade de estudos relativos ao problema da determinação das espécies, em fases iniciais do desenvolvimento, temos realizado uma série de estudos morfológicos e anatômicos das sementes e plântulas de espécies de *Eucalyptus* cultivadas no Brasil (1, 2, 3, 4, 5, 6, 7) visando fornecer subsídios para sua identificação, bem como para possíveis estudos taxonômicos e ecológicos. As espécies já estudadas, ora acrescentamos *Eucalyptus intermedia* R. T. Baker.

Material e métodos

As sementes de *Eucalyptus intermedia* utilizadas no presente trabalho são provenientes do Horto Florestal "Navarro de Andrade" de Rio Claro (SP), colhidas de matrizes selecionadas.

Os aspectos morfológicos externos e internos das sementes férteis e estéreis foram estudados utilizando-se um esteriomicroscópio.

As determinações de peso de 100 sementes férteis bem como a porcentagem média de sementes férteis (em peso), foram feitas através de amostras casuais, em balança analítica. Observou-se, também, o número médio de sementes férteis por grama de sementes misturadas. Na determinação das dimensões médias das sementes foi utilizada uma ocular de medição aferida com lâmina micrométrica.

As investigações anatômicas foram feitas em sementes previamente embebidas em água, através da observação de seções transversais, longitudinais e paradérmicas, realizadas a mão livre. Os cortes foram montados em glicerina a 10%, conseguindo-se preparações semi-permanentes (11).

A natureza microquímica das paredes e conteúdos celulares foram determinados utilizando-se os testes usuais (10, 11, 12).

Os desenhos e diagramas foram feitos em câmara clara, adaptada a um microscópio ótico binocular.

Para se observar sua germinação, as sementes foram colocadas em placas de Petri, sobre papel de filtro úmido e mantidas em condições de luminosidade e temperatura ambientes (média de 25°C).

Resultados

Nas amostras estudadas de *Eucalyptus intermedia* foram encontradas sementes aparentemente viáveis,

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providas de embrião e sementes estéreis de dois tipos, A e B, desprovidas de embrião que podem ser distintas principalmente pela forma, dimensões e coloração.

Foram encontradas em média 66± 4% (em peso) de sementes férteis, sendo 258± 5 sementes férteis por grama de sementes misturadas. O peso médio de 100 sementes férteis foi de 487.2± 91.5 mg.

Características das sementes férteis (Figuras 1 a 3): formas, em geral, ovoides ou turbinadas; providas de longa asa terminal fina e translúcida que se estende pelos bordos laterais como uma expansão que gradativamente se estreita e toma cerca de metade do comprimento total das sementes. Estas são achatadas laterlamente, com quilha muito proeminente e hilo ventral ou, achatadas de um dos lados, com hilo lateral. São de coloração castanho-claro, avermelhado; superfície lisa na face dorsal, pouco brilhante e com rugosidades na face ventral; bordo inteiro; hilo ovado, grande e bem distinto, de coloração clara; micrópila localizada na extremidade inferior da semente, não visível na semente seca (Figura 11); região da chalaza marcada por mancha circular, mais escura, logo acima do hilo; rafe ausente. Medem em média 8.61 ± 1.19 mm de comprimento por 2.13 ± 1.19 mm de comprimento por 2.13 ± 0.27 mm de largura (incluindo a asa).

Características das sementes estéreis (Figuras 4 e 5) – **Tipo A** – alongadas: irregulares, turbinadas ou falcadas, às vezes com uma extremidade translucida; coloração marrom médio, alaranjado; superfície pouco brilhante; hilo basal, medindo em média 4.00 ± 0.54 mm de comprimento por 0.62 ± 0.12 mm de largura.

Tipo B – achatada: irregular, com uma extremidade translúcida; marrom médio, alaranjado; superfície pouco brilhante; hilo basal, medindo em média 2.05 ± 0.41 mm de comprimento por 0.79 ± 0.13 mm de largura.

Morfologia interna da semente fértil:

A semente fértil, madura, tem como envoltórios dois tegumentos, além de remanescentes do nucelo e do endosperma. O embrião (Figuras 17 e 18) apresenta dois cotilédones espessos, dobrados (Figura 15) e inseridos próximo da extremidade superior do eixo hipocótilo-radicula (Figura 16).

O eixo hipocótilo-radicula é cilindrico e mede cerca de 2.1 mm de comprimento por 0.5 mm de diâmentro. É constituido pelo hipocótilo havendo, em extremidades opostas, os meristemas caulinar e radicular. Este último, recoberto pela coifa, é, em parte, envolvido pelo órgão cupuliforme que é uma saliência do córtex do hipocótilo (Figura 16).

Anatomia dos envoltórios da semente fértil:

O tegumento externo (testa), que é a camada pigmentada do envoltório da semente, consta de duas epidermes, entre as quais ocorre um número variável de camadas de células parenquimáticas tabulares, nem sempre muito distintas. Na face ventral da semente, bem como na asa e nas outras expansões da testa (Figuras 8, 9 e 13), há sempre várias camadas. Na face dorsal há sempre menor número de camadas e às vezes apenas uma (Figura 6).

A epiderme externa (exotesta) é revestida por uma cuticula e consta de células retangulares ou quadradas em seção transversal (Figura 6) e hexagonais ou poliédricas em seção paradérmica (Figura 7). Estas células contém densos depósitos amorfos de substâncias tânicas, de coloração vermelha, rapidamente solúveis em água ou álcool.

A epiderme interna (endotesta) é constituida de células retangulares em seção transversal (Figura 6) e pentagonais ou hexagonais em seção paradérmica (Figura 7). Cada célula apresenta um forte espessamento lamelar em sua parede periclinal interna e contém um ou mais cristais de oxalato de cálcio.

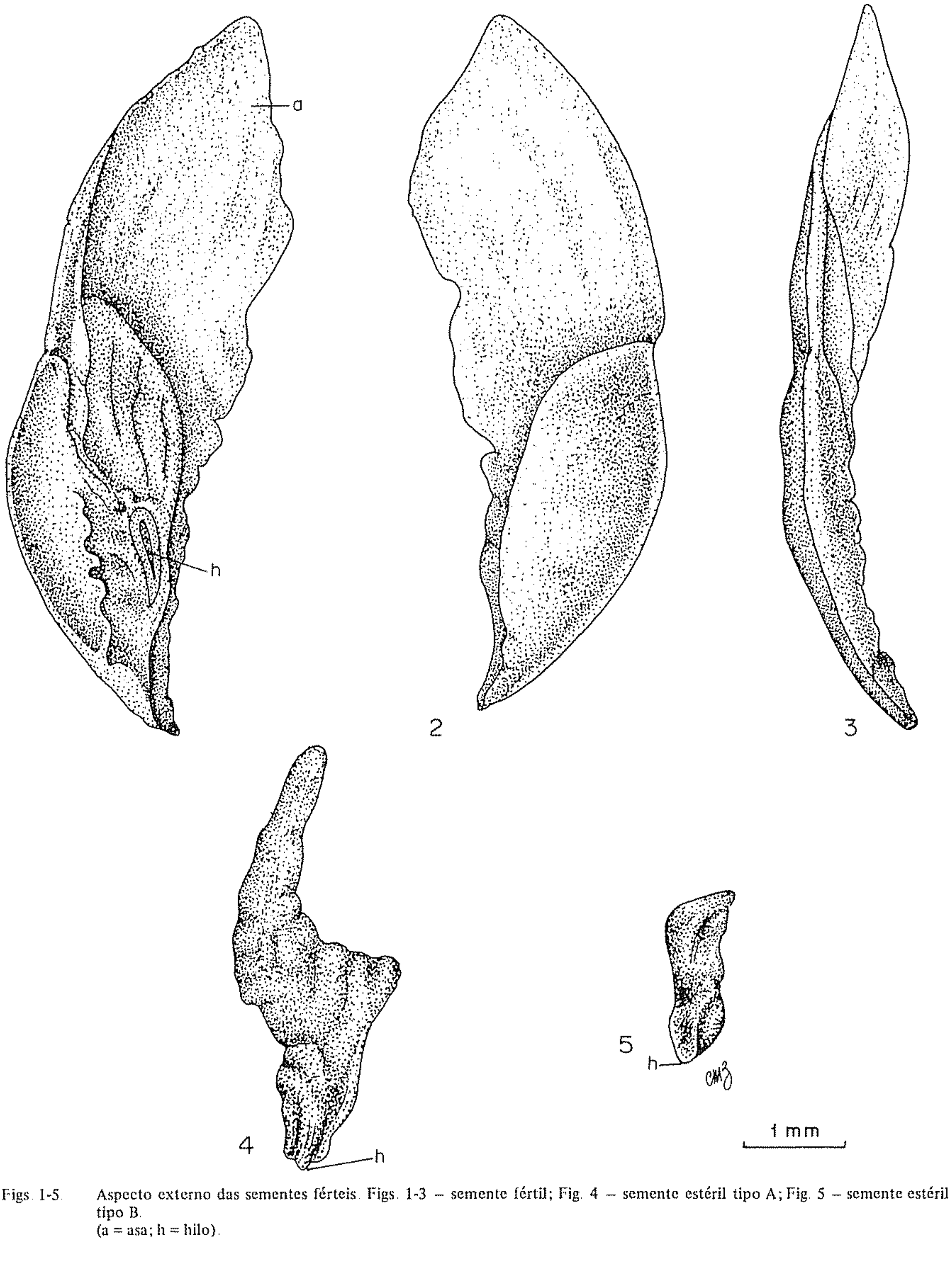
A asa é uma longa expansão do tegumento externo, da qual não participa a endotesta (Figura 9).

O tegumento interno (tégmen) encontra-se quase que totalmente reabsorvido, distinguindo-se duas camadas de células não suberificadas, apenas nas proximidades da chalaza (Figura 13). Separa-se da camada subjacente os remanescentes do nucelo, por uma cuticula bem visivel (Figura 8 e 13) que emite longas projeções por entre as células do nucelo. Este consta de um número variável de camadas de células muito obliteradas e só distintas na região da chalaza.

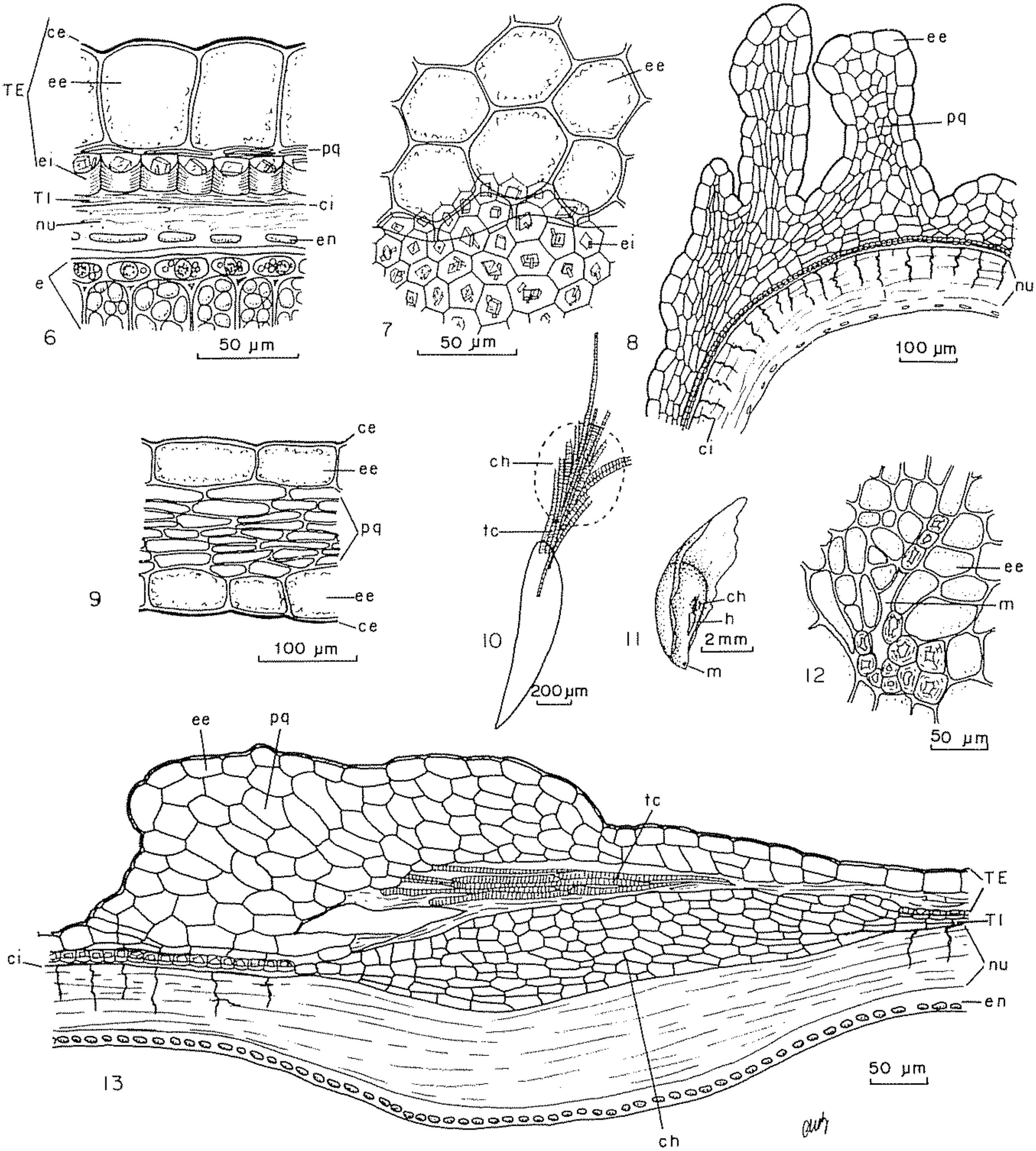
Do endosperma resta uma só camada de células que contêm substâncias proteicas e goticulas de óleo (Figura 6).

O tecido da chalaza (Figura 13) é suberificado, sendo que as células contêm material tânico denso, de coloração marrom-avermelhado.

Do bordo superior do hilo parte um único feixe vascular colateral que se dirige diretamente à chalaza



Figs. 1-5. Aspecto externo das sementes férteis. Figs. 1-3 – semente fértil; Fig. 4 – semente estéril tipo A; Fig. 5 – semente estéril tipo B.
(a = asa; h = hilo).



Figs. 6-13 Anatomia dos envoltórios da semente fértil. Figs. 6 e 7 – respectivamente setores de seções transversal e paradérmica dos envoltórios da semente fértil (face dorsal); Fig. 8 – seção transversal através das rugosidades existentes nas proximidades do hilo; Fig. 9 – seção longitudinal da asa; Fig. 10 – padrão de vascularização; Fig. 11 – diagrama da semente mostrando a posição do hilo da micrópila e da chalaza; Fig. 12 – seção paradérmica na região da micrópila; Fig. 13 – seção longitudinal mediana da chalaza.

(ch = chalaza; ce = cuticula externa; ci = cuticula interna; e = embrião; ee = epiderme externa; ei = epiderme interna; en = endosperma; h = hilo; m = micrópila; nu = nucelo; pq = parênquima sub-epidérmico; tc = tecido condutor; TE = testa; TI = tégmen).

onde se ramifica (Figuras 10 e 13). Algumas das ramificações mais longas ultrapassam a região da chalaza.

A superfície do hilo é constituida por células de paredes finas, parcialmente soltas ou rompidas. A micrópila é uma abertura alongada, rodeada por pequeñas células epidérmicas de paredes finas, entre as quais ocorrem alguns grupos de escleritos (Figura 12).

Anatomia do embrião:

O eixo hipocótilo-radicular (Figura 14) é revestido pela protoderme, composta de células cúbicas, da qual partem pequenas glândulas de óleo que são também abundantes em ambas as faces dos cotilédones. Sob a protoderme, como precursor do córtex, aparecem 7 a 8 camadas de células arrendondadas do meristema fundamental que também ocorre no centro, como precursor da medula. O cilindro procambial (Figuras 14 e 16) consta de 3 a 8 camadas de células longas e estreitas, de paredes muito finas. No ápice do hipocótilo divide-se em dois ramos, que se dirigem aos cotilédones. As células protodérmicas na face adaxial dos cotilédones (Figura 19), apresentam cada qual alguns pequenos grãos de aleurona, em torno de um bem maior, no interior do qual aparece, além de outras inclusões, grande drusa de oxalato de cálcio ou um cristal prismático solitário. Na face abaxial essas drusas e cristais solitários são bem menores e, geralmente, não aparecem em todas as células.

Na face adaxial, sob a protoderme, ocorre uma camada de células dispostas em paliçada e a seguir 5 a 6 camadas de células arrendodadas que deixam espaços intercelulares.

Os tecidos do embrião, exceto o procâmbio e as células glandulares (ricas em óleo), contêm grãos arredondados de aleurona e gotículas de óleo (Figuras 14 e 19).

Germinação e caracteres morfológicos da plântula:

Ao serem colocadas em condições favoráveis, as sementes logo se embebem e, em 4 ou 5 dias, rompem os tegumentos na região micropilar, emergindo a radícula, parcialmente envolvida pelo órgão cupuliforme (Figura 20). Este, que depois de desenvolvido mede cerca de 0.7 mm de largura, logo se reveste de uma corôa densa e uniforme de longos pelos absorventes (Figura 21) que, em sete ou oito dias, se fixam ao substrato (Figura 22), e em 8 a 10 dias os tegumentos são rejeitados (Figura 23). O órgão cupuliforme mantém-se funcional por cerca de vinte e cinco a trinta dias, ocasião em que os pelos começam a secar.

A radícula alonga-se rapidamente, desenvolvendo pelos absorventes mais curtos e, em cerca de vinte dias (Figura 24), já apresenta ramificações. O hipocótilo também cresce, adquirindo, aos poucos, coloração verde-claro e, desde o início, apresenta, em toda sua superfície, numerosas emergências glandulares em cujo interior observa-se uma gota de óleo essencial. Estas, na região inferior do hipocótilo, são levemente róseas devido à presença de antocianinas. Na região superior do hipocótilo, nos pecíolos dos cotilédones, no epicótilo e na plúmula, onde também aparecem, não apresentam pigmentos.

Os cotilédones desdobram-se em cerca de quinze dias, sendo reniformes e bem verdes em ambas as faces e, em aproximadamente vinte dias, o epicótilo inicia seu crescimento (Figuras 24 e 25).

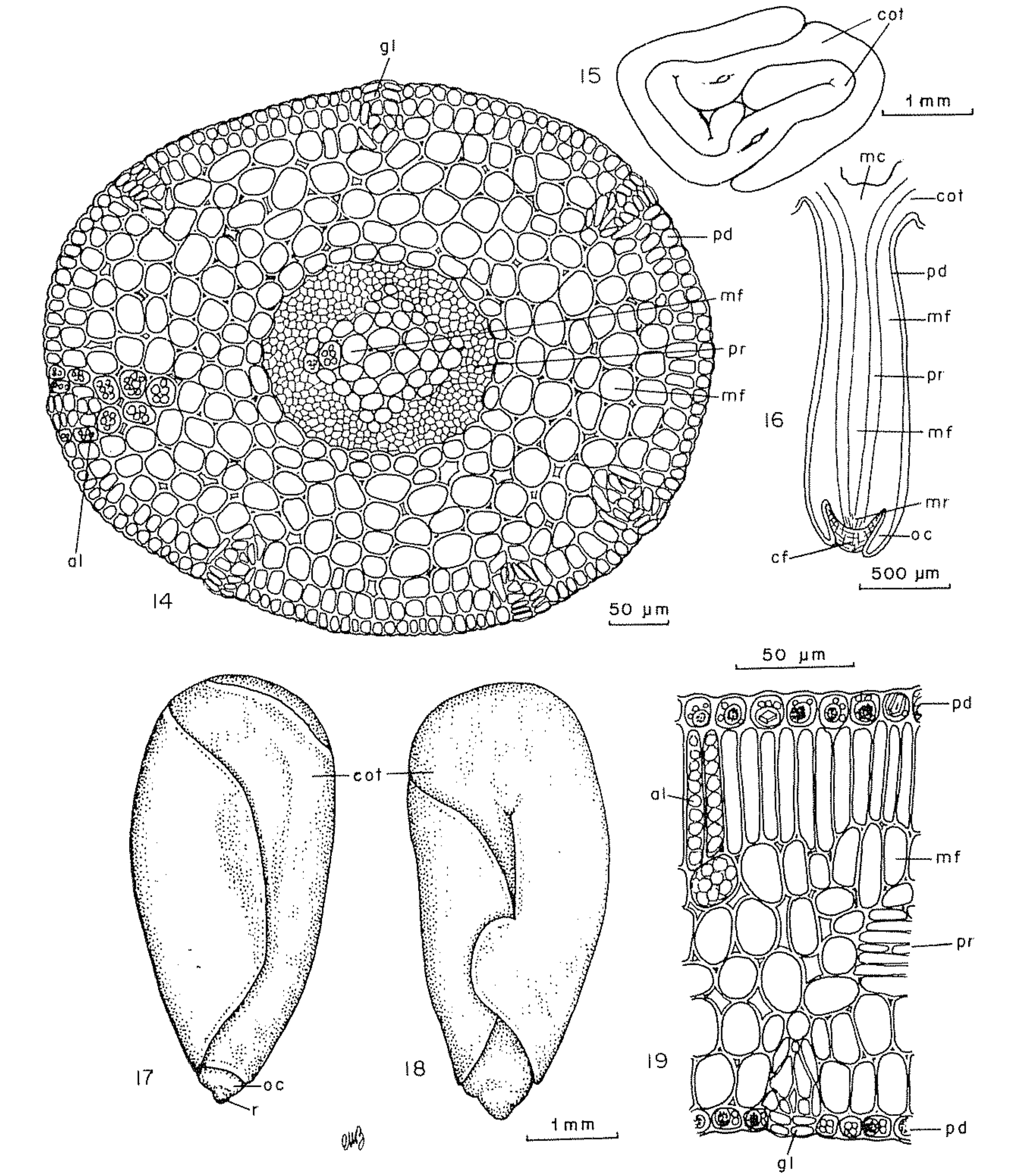
Discussão

Comparando-se as sementes de *Eucalyptus intermedia* com as de espécies previamente estudadas (1, 2, 3, 4, 5, 6, 7), verifica-se que as características superficiais e a anatomia principalmente da testa são de grande importância na identificação das sementes.

As sementes de *Eucalyptus intermedia* apresentam alguns caracteres morfológicos e anatômicos que as podem distinguir prontamente das demais. Dentre estes, o mais evidente é a ocorrência de longa asa membranosa terminal que faz com que a semente se mova helicoidalmente durante e disseminação. A presença da asa é característica de certos grupos de Corymbosae e única no gênero (9).

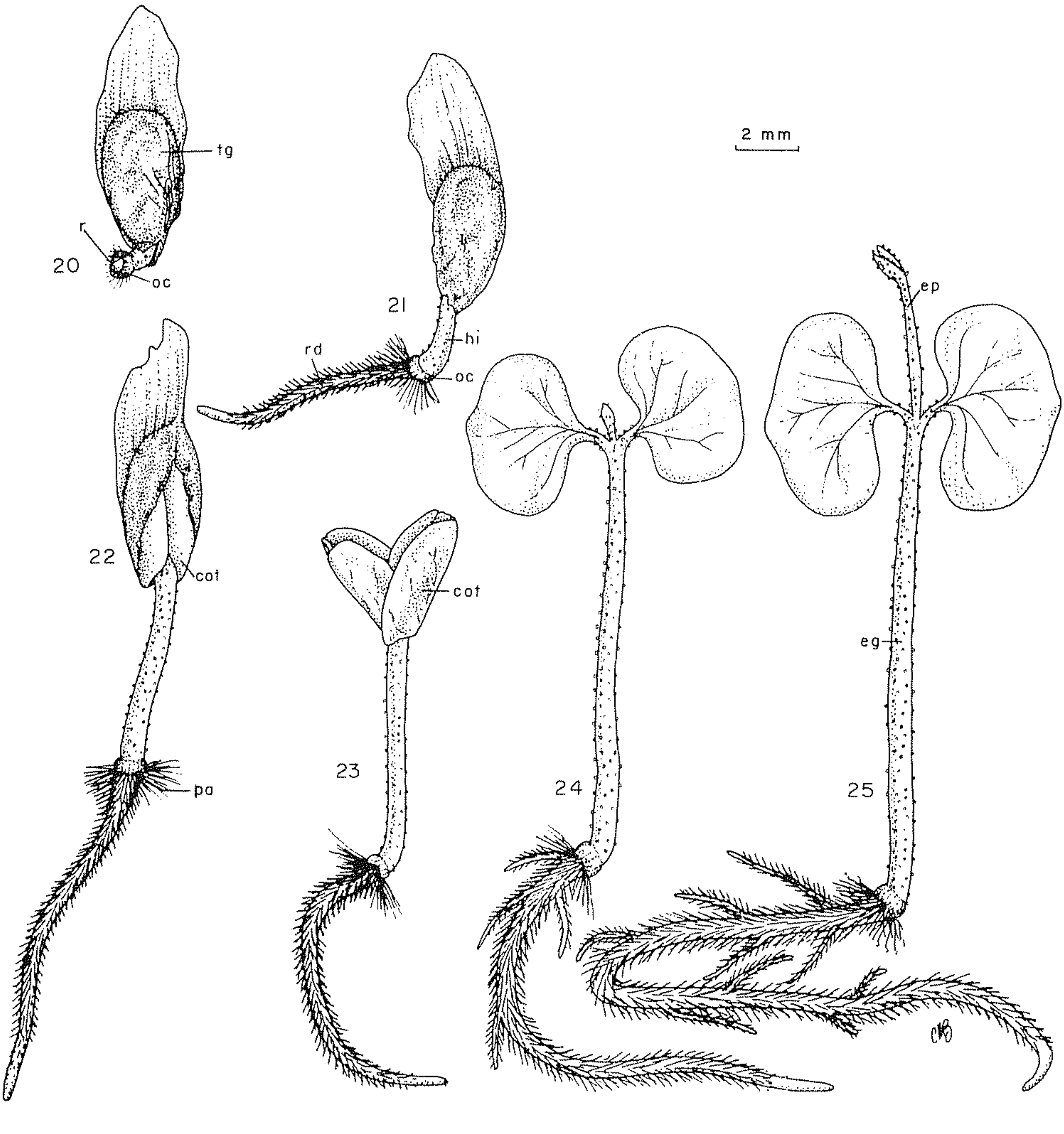
Como, em geral, as sementes de *Eucalyptus* são de dimensões muito reduzidas. Outro carater importante na identificação das sementes de *Eucalyptus intermedia* é o comprimento médio das sementes férteis. Usando a técnica de Kruskal-Walles (13) para comparaçoes entre médias de comprimento das sementes férteis, observou-se ser este significativamente maior em *Eucalyptus intermedia* do que nas demais espécies por nós estudadas.

As características do embrião e da plântula são relativamente mais uniformes entre as diversas espécies de *Eucalyptus*, porém, um aspecto distintivo no embrião é a presença, em todas as células da epiderme abaxial e, esparçamente na epiderme adaxial do cotilédone, de uma drusa ou de um cristal prismático solitário de oxalato de cálcio, no inte-



Figs. 14-19. Embrião.
Fig. 14 – seção transversal mediana através do eixo hipocótilo-radicular; Fig. 15 – Diagrama da seção transversal dos cotilédones; Fig. 16 – Diagrama da seção longitudinal através do eixo hipocótilo-radicular; Fig. 17 – aspecto externo do embriao (face ventral); Fig. 18 – aspecto externo do embrião (face dorsal); Fig. 19 – setor de seção transversal do cotilédone.

(al = graõs de aleurona; cf = coifa; cot = cotilédone; gl = glândula; mc = meristema caulinar; mf = meristema fundamental; mr = meristema radicular; oc = órgão cupuliforme; pd = protoderme; pr =procâmbio; r = radícula).



Figs. 20-25. Estágios sucessivos de desenvolvimento da plântula, após a colocação das sementes em condições de germinação. Fig. 20 – plântula após 4 dias; Fig. 21 – plântula após 6 dias; Fig. 22 – plântula após 8 dias; Fig. 23 – pllântula após 10 dias; Fig. 24 – plântula após 21 dias; Fig. 25 – plântula após 30 dias.

(cot = cotilédone; eg = emergências glandulares; ep = epicótilo; hi = hipocótilo; oc = órgão cupuliforme; pa = pelos absorventes; r = radícula; tg = tegumento) rior de um grão de aleurona. Estrutura semelhante foi observada em *E. citriodora* e em *E. maculata* (3). Além disso, nestas mesmas espécies, aparecem emergências glandulares na plântula, como foi também observado em *E. intermedia* e não em outras espécies. Esses caracteres, portanto, parecem ter valor taxonômico, uma vez que essas três espécies, são incluidas na mesma série, Corymbosae-Peltatae (8).

Resumen

Se estudiaron en detalle aspectos morfológicos y anatómicos de semillas y plántulas jóvenes de *Eucalyptus intermedia* R. T. Baker, con énfasis en la estructura de los tegumentos y del embrión, con el propósito de establecer una base para su identificación.

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HABITAT USE BY GUANACOS (*Lama guanicoe*) AND SHEEP ON COMMON RANGE, TIERRA DEL FUEGO, CHILE[1] /

*KENNETH J. RAEDEKE**

Resumen

Se analizó el impacto de la introducciòn de ganado ovino en el habitat de los guanacos, comparando el nicho ambiental del guanaco antes de la introducción del ganado, con el nicho después de la misma Se comparó el habitat autóctono del guanaco, reconstruido a partir de información literaria, con los nichos ambientales actuales tanto de las ovejas como de los guanacos, en Isla Grande, Tierra del Fuego, Chile, 1972–1975. Los modelos de empleo del habitat se determinaron mediante censos de campo de los guanacos, registros de existencia de ganado ovino, y observaciones del campo acerca del empleo del habitat por parte de ambas especies.

El nicho ambiental de las ovejas, en su enteridad, cabe dentro de los limites del habitat original del guanaco. Desde la introducción del ganado, el guanaco se ha encontrado desplazado de su habitat autóctono, actualmente ocupado por las ovejas que apenas dejan franjas marginales sin ocupación. Evidencias indirectas sugieren que la competencia con las ovejas eliminó al guanaco. En las áreas donde no existe ganado ovino, los guanacos manifiestan modelos de empleo del habitat similares a los de su nicho ambiental autóctono.

Introduction

The guanaco (*Lama guanicoe*) was once the most common and characteristic ungulate of temperate South America (4). However, since Darwin's time, the guanaco populations have been drastically reduced both in numbers and distribution (3, 8, 16, 19). The principal cause of the decline has been attributed to indiscriminate hunting of the guanaco for food, hides, and to eliminate the guanaco as a possible competitor with domestic stock (5). However, recent studies have shown that the factor currently most important in regulating guanaco numbers is competition with domestic stock, principally sheep, for the available forage of the range (16). This paper deals with one aspect of this competition, the patterns of habitat utilization by both species on common range. The patterns of forage utilization by sheep and guanacos have been given by Raedeke (15, 16, 17).

The interactions of sheep and guanaco populations were analyzed by comparing habitat use of both species under varying degrees of population interaction. First, the aboriginal habitat niche of the guanaco was reconstructed from published historical accounts. Second, the current habitat niches of the guanaco and sheep populations were determined from field studies of habitat use on Isla Grande, Tierra del Fuego, Chile. Third, the impacts of the sheep on the guanaco population was analyzed by comparing the aboriginal (fundamental) and current (realized) niches of the guanaco, and the niche shifts that occur with seasonal changes in interactions with sheep.

The field studies described in this paper were conducted by the author from 1972 to 1975. This

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work is a part of the wild-life research program of the Corporación Nacional Forestal of Chile, and additional support was provided by the United States Peace Corps, and the World Wildlife Fund Grant 879. The Instituto de la Patagonia and the Servicio Agrícola y Ganadero made their laboratory facilities available for use in the study.

The study area

All materials included in the analysis were collected from the center region of Isla Grande in the area between 69 and 70 degrees west longitude and 53 and 54 degrees south latitude. This area is within the Rio Grande river basin, at the interface of the continuous beech forest along the foot of the precordillera on the south, and the open steppe grasslands on the north. The habitat consists of a mosaic of plant communities including beech forests, matorral shrub lands, sphagnum bogs, and the steppe grasslands. The tree species include nirre (*Nothofagus antarctica*) and lenga (*Nothofagus pumilio*), both of which are deciduous. The principal shrubs are michay (*Berberis ilicifolia*), calafate (*Berberis buxifolia*), and romerillo (*Chiliotrichim diffususm*). The latter shrub is a common increaser in the matorral and grassland communities. The dominant grasses are coiron (*Festuca gracillima*, *F. pallescens*, and *F. magellanica*) and various species of the genera *Stipa*, *Deschampsia*, and *Poa*. Common herbaceous plants belong to the genera *Ranunculus*, *Acaena*, *Senecio* and others. More detailed descriptions of the flora of the region are given by Auer (1), Humphrey *et al.* (6), Pisano (12, 13), and Raedeke (16).

The study area ranged in elevation from 200 to 400 meters. The topography is characterized by rolling hills and plains dissected by numerous small streams and rivers. Large lakes fill the glacier scoured valleys of the precordillera hills on the south. The entire area is grazed by sheep, domestic cattle, and horses. In 1975, the study area of 200 000 hectares supported a herd of 140 000 sheep.

The climate is characterized by cool dry summers, and rain and snow in the winters. The mean annual precipitation is 300 to 450 mm. The growing season is too short to allow cultivated crops to ripen, except in the areas with favorable microclimates.

Methods

Habitat use by the guanacos before the introduction of sheep has been assimilated from the few published accounts of guanaco life history, distribution, and general observations.

Current habitat use by both guanacos and sheep was determined by calculating the animal densities supported in the different habitat types in the Rio Grande river basin on Tierra del Fuego. The guanaco densities and distributions by habitat were calculated from line transect censusing and aerial surveys. The detailed methodology and results are given in Raedeke (16). The sheep densities were determined from the stocking records of the local ranches and the Chilean agricultural agencies. The distribution of range use by both guanacos and sheep within the different macrohabitats were determined by direct field observations, presented in detail in Raedeke (16).

Results

Original Habitat Use by Guanacos

Before the introduction of sheep, the preferred habitat of the guanaco was the open grasslands of Patagonia. The early naturalists all indicated that the highest densities of guanacos were found on the pampa (4, 14, 18, 19), especially on the fertile, moist river plains. Rogers (18) counted over 5 000 guanacos in one day on the pampa, and calculated the population to be over 1.5 million guanacos in the area south of the Rio Santa Cruz in Argentina. The scrublands in the foothills of the Andes at the fringes of the grasslands also supported large numbers of guanacos, but this was definitely regarded as secondary habitat (4).

Forested areas apparently did not support large guanaco populations. Prichard (14) noted that he saw no guanacos in the forested regions in all his travels through Tierra del Fuego. Other authors either inferred that the guanaco was not abundant in the forest (9, 19), or noted only slight use of the forest habitat (3, 5). The observations of Cardozo (3) and Dennier de la Tour (5) are particularly interesting, since even though by 1954 most of the guanacos of the pampa had already been eliminated, these biologists still considered the forest to be only marginal habitat for the remaining guanaco populations. Bridges (2) was the first to suggest that the forest was adequate guanaco habitat, although inferior to the grasslands of central Isla Grande.

From these observations, it is possible to reconstruct an idealized distribution of guanacos along a vegetation ecocline. Figure 1 illustrates the reconstructed guanaco densities along the vegetation-

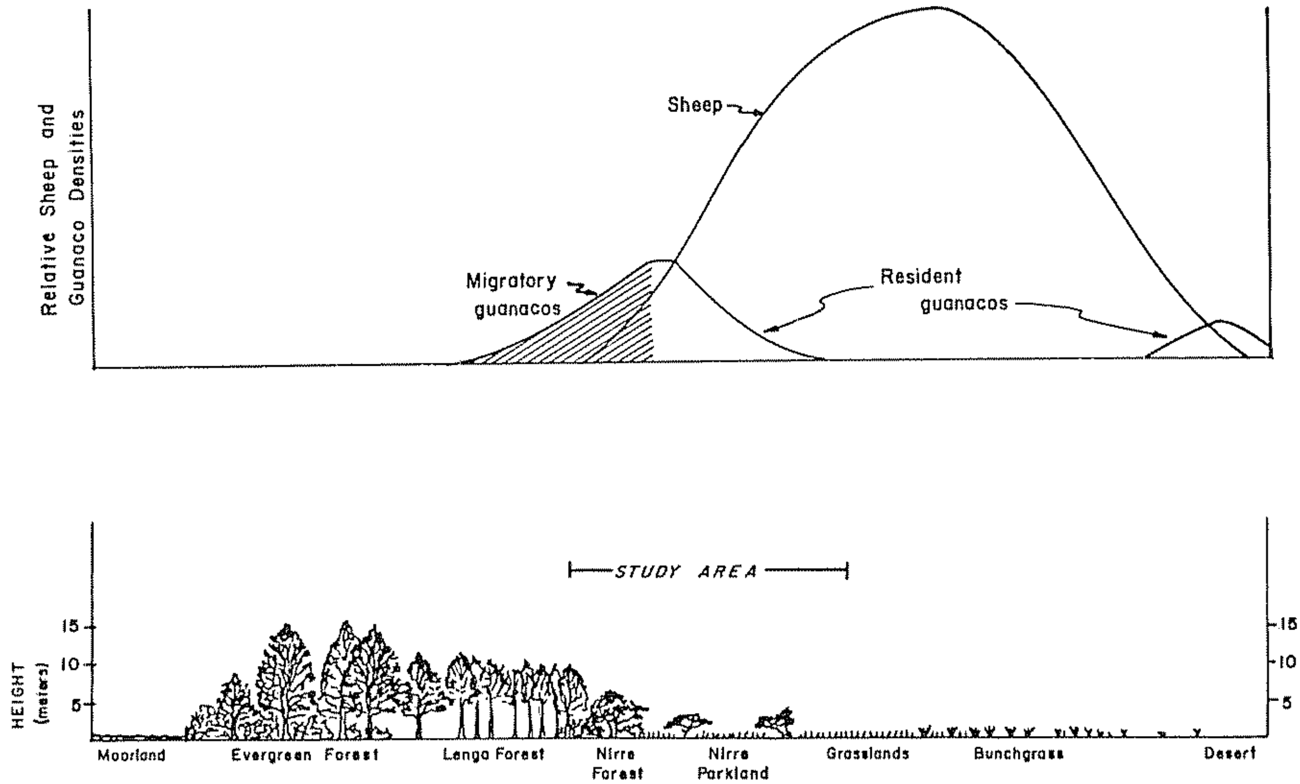

Fig. 1. Reconstructed guanaco densities along the habitat ecocline across Isla Grande, Tierra del Fuego, Chile.

moisture gradient, extending from the cool and damp on the left (west), to warm and dry on the right (east). This ecocline roughly represents the transition from the wet, temperate evergreen forests and moorlands on the west side of the South American continent to the coastal deserts on the east side of the continent. The grasslands in the ecocline are equivalent to the grasslands in the Rio Grande Basin of the study area.

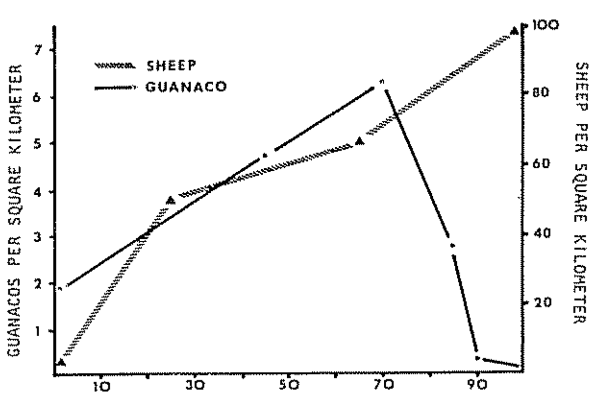

Fig. 2. Guanaco and sheep densities along the habitat ecocline in the intensive study area, Rio Grande Basin, Tierre del Fuego, Chile.

Current Habitat Use by Guanacos and Sheep

During the present study, both guanacos and sheep were widely distributed throughout the study area, and both species utilized all macro-habitat types to some extent. However, each habitat characteristically supported different relative densities of the two species.

The habitat use patterns for the sheep and guanacos on the study area are given in Figure 2, which plots the densities of the non-migratory guanacos and sheep across the pampa-forest ecocline. This figure represents the section of the ecocline in Figure 1 from the grasslands to the edge of the continuous beech forest. Since the sheep used the area seasonally, the sheep densities were corrected to represent annual average densities. Furthermore, if the migratory guanacos were included, the guanaco densities in the forest end of the continuum would increase from 1.8 to about 6.0 guanacos per square kilometer.

The guanaco densities were greatest at the ecotone between the forest and the open grasslands in the southern part of the study area. Guanacos were seldom seen more than one or two kilometers from the forest, having apparently been almost completely excluded from the open pampa.

Sheep densities were greatest on the open pampa, and decline almost linearly with the increase in forest cover. No sheep are found to use the continuous beech forest area in the southern portion of the Rio Grande basin in Chile.

Vegetation, not topography, appears to be the basis of range partitioning between sheep and guanacos, since both sheep and guanacos readily graze and travel on even the steepest terrain. Stoddart *et al* (21) reported that the domestic sheep is second only to the goat in the ability to distribute itself and to graze on all terrain types. Furthermore, the herding of sheep, the use of fenced pastures, and rotational grazing insured that the sheep utilized all the suitable topography of the region.

Changes in Habitat Use by Guanacos Sympatric with Sheep

Both direct observation and food habits data (16, 17) indicate that when guanacos and sheep were found together the guanacos used their habitat differently than when alone. With sheep competition, both in the summer and winter, the guanacos utilized the forest habitat to a greater extent than when sheep were few or absent. This does not seem to be due to a general reduction in the quality of the grasslands or weather patterns, since the sheep should also respond to such changes in the habitat, but they did not.

The proportion of the guanaco population observed on the pampa decreased when the area was also occupied by sheep. A comparison of the guanaco habitat use on the sheep winter range in the northeast section of the study area demonstrates this shift. The estimated guanaco densities were at least three times as great on the pampa as in the forest during the summer, when sheep were absent from both habitats (Table 1). However, in the winter when sheep were present on the pampa, the guanaco densities were greater in the forest than on the pampa. The winter ratio of the densities of forest to pampa were 1.3:1 in 1972, 2.4:1 in 1973, and 1.6:1 in 1974. A similar shift was observed on other seasonal range types.

Discussion

The distribution and density of the guanacos in the various habitat types within the province has changed dramatically since aboriginal times, as represented in Figure 1. Sheep herds have been

Table 1. Summer guanaco densities* for forest and pampa habitats in the intensive study area, Rio Grande Basin, Tierra del Fuego, Chile (from Raedeke).

Year	Forest	Pampa
1972	0.38 ± 0.23	1.42 ± 0.40
1973	0.13 ± 0.09	1.19 ± 0.28
1974	0.31 ± 0.13	1.29 ± 0.33

* The densities are given as guanacos per square kilometer ± 95% confidence interval.

sucessfully established in all the economically viable sheep habitats of the province, with the resultant concentration of sheep on what was the most productive part of the guanaco range. Sheep are now grazed in all habitats represented in the ecocline in Figure 1 that are east of the evergreen forest. The present guanaco population is concentrated at the interface of the forest and grasslands, in the forests of the south and west, and at the eastern (dry) fringes of the sheep range. Thus, the guanaco survives largely in marginal habitats, with the major former habitat now being preempted by sheep.

The habitat niche of the domestic sheep is entirely included within the habitat niche of the guanaco, and sheep grazing has apparently eliminated the guanaco from much of its former range. In Figure 3 the idealized relative densities of the current guanaco and sheep populations are plotted along the macrohabitat ecocline, based on the results of this study. The figure shows that the sheep, with their more restricted habitat preference, have supplanted the guanacos in the center of their former habitat (see Figure 1), and are sympatric with the guanacos at the fringes of their own range. In the extreme edges, the deserts and the closed forest communities, the sheep have not become established, and the guanacos exist alone at low population densities.

Circumstantial evidence suggest that competition with introduced sheep for the range habitat and forage is the ultimate factor causing the exclusion of the guanaco from much of its former range

First, guanacos have successfully repopulated areas where sheep have been removed. Rottman (per. comm.) reported an annual guanaco population increase of approximately 10% for guanacos repopulating vacated sheep range in an area that had been annexed to a national park. Sheppard (20), Pianka (10), and Krebs (7) stated that the expansion of one species population subsequent to the removal of its competitor is the best evidence for competitive

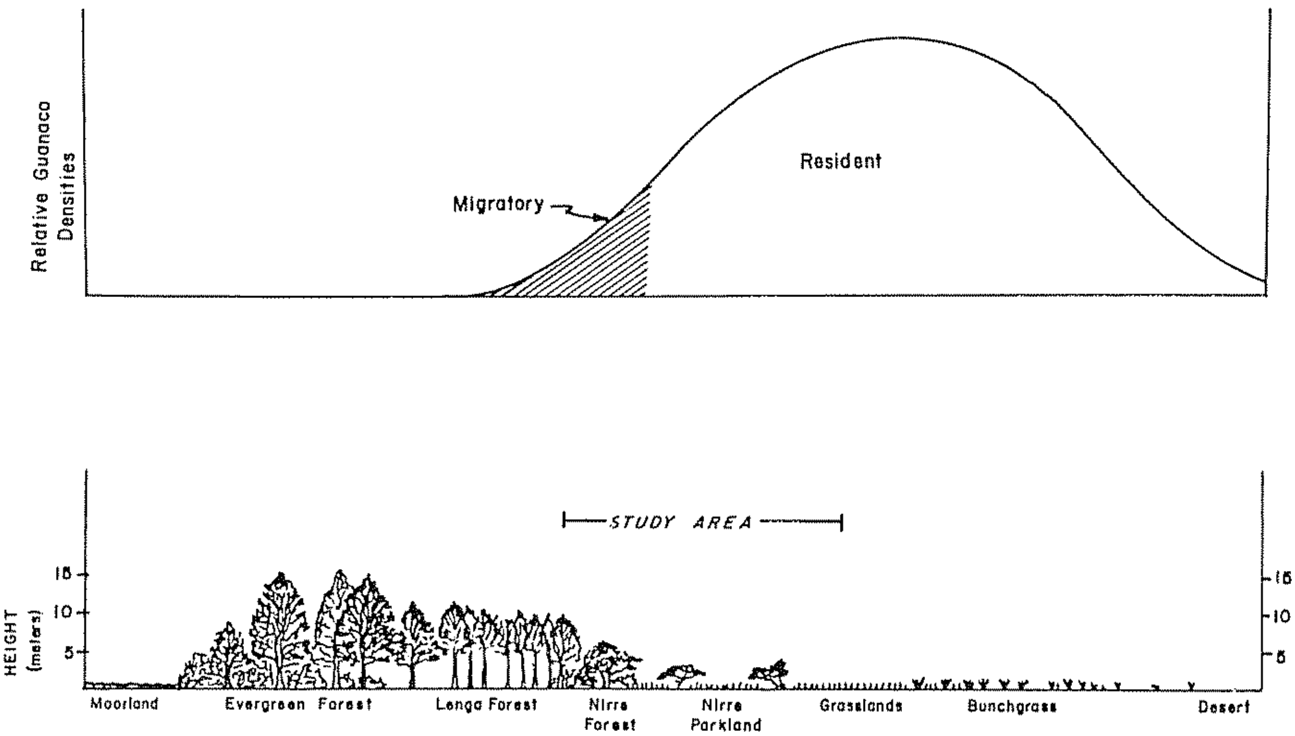

Fig. 3. The relative densities of guanacos and sheep along the habitat ecocline across Isla Grande, Tierra del Fuego, Chile.

exclusion. Pianka (11) called this phenomenon "ecological release."

Second, within the province, there are areas that are prime sheep range, but due to natural hazards, these areas, guanaco populations often thrive. The best example is the guanaco population within the area fenced off around the Pali-Aike lava beds in the northeast sector of the province. Within this small area of less than 75 square kilometers, 500 guanacos were censused in 1975 (15).

Direct evidence of competitive exclusion of guanacos by sheep comes from the observation of habitat populations often thrive. The best example is the guanaco shifts with seasonal increases in sheep numbers of the study area. Guanacos shifted from heavily utilizing the open grasslands where sheep were not present to greater use of the forest patches when sheep were present in large numbers. This was observed both on summer and winter ranges.

This later observation of seasonal habitat shifts makes it appear that competitive exclusion was caused by interference competition. However, sheep are not physically or behaviorally dominant over guanacos, and did not displace guanacos through social interactions, since it was common to observe sheep and guanacos grazing interspersed on the grasslands without conflict. Instead, the movement of sheepherders and their dogs tending the sheep appeared to displace the guanacos for a period of time. Be this as it may, even if guanacos were not displaced by sheep and the herders due to interference, the guanacos would eventually be displaced by the depletion of the forage resource due to sheep grazing (i.e., exploitation competition). The typical heavy grazing pressures of sheep on the ranges in the area reduces the carrying capacity of the ranges for guanacos through nearly complete seasonal depletion of the forage. Hence, guanacos that had been displaced by sheep would face a greatly reduced survival due to a reduction of forage if they returned to thir former range after the sheep had been removed. Thus, competition by exploitation of the forage resource by sheep appears to be the ultimate cause of some shifts in guanaco habitat use.

Summary

The impact of the introduction of domestic sheep on the habitat used by guanacos was analyzed through a comparison of the habitat niche of the guanaco before and after the introduction of sheep. The aboriginal habitat niche of the guanaco, reconstructed

from literature accounts, was compared to current habitat niches of both sheep and guanacos on Isla Grande, Tierra del Fuego, Chile, 1972–1975. The patterns of habitat use were determined through field censuses of guanacos, sheep stocking records, and field observations of habitat use by both species. The habitat niche of the sheep is entirely included within the original habitat niche of the guanaco. Since introduction of sheep, the guanaco has been displaced from its aboriginal habitat, now occupied by sheep, except on the fringes of the sheep distribution. Circumstantial evidence suggests that the guanacos were excluded by competition with sheep. Where sheep are not present, guanacos show habitat use patterns similar to their aboriginal habitat niche patterns.

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EFFECT OF HERBICIDE APPLICATION ON LEGUME *Rhizobium* SYMBIOSIS WITH AND WITHOUT STARTER NITROGEN[1] /

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*A. ADEBAYO**
*O. ODEYEMI***

Resumen

Se estudia el efecto de tres formulaciones de herbicidas, Preforan (2-4-dimitro-4-trifluormetil-difenil eter), Dacthol (dimetril 2,3,5,6- Tetracloroteriftalato) y Dival (2-etil-6 metil- 2-metoxi-1-etil)-a-cloroacetinilida) sobre la simbiosis leguminosa Rhizobium *con y sin nitrógeno como iniciador. El estudio se llevó a cabo en medio arenoso bajo condiciones de invernadero.*

Los resultados indican que en el caupi tratado con Dual presentó un menor peso de nódulos secos (1.56 mg/planta) que el Preforam o el Dacthol cuyos nódulos pearon 3.50 y 3.75 mg/planta respectivamente. El herbicida Dual también causó una disminución del N fijado pues las plantas así tratadas contenían 0.27% N mientras que plantas tratadas con Preforam y Dacthol contenían 0.35% N y 0.42% N, respectivamente.

La adición de nitrógeno como iniciador produjo 117 mg/planta de sustancia seca, en contraposición con 66.2 mg/planta obtenida en plantas inoculadas sin aplicación de N.

Introduction

It has become well-established that the legume *Rhizobium* symbiosis contributes highest to the N reserve of the ordinary soil compared with other biological contributors (2). This contribution becomes particularly important in tropical farm management practices where not much fertilization is done. However, in recent times, the problem of biological N accumulation in soils has been compounded by the indiscriminate introduction and use of herbicides in many tropical countries. The use of herbicides is being recommended without proper evaluation of their effect on the microbiological balance, especially on such an important natural process as symbiotic nitrogen fixation.

In a recent study, Parker and Dowler (12) showed that the application of Trifuralin to soybean resulted in reduction of nodule number. However, it was not clear whether this reduction was due to herbicidal injury on the host plant or on the *Rhizobium* component. There is no doubt from the above cited studies that any herbicide being introduced into the soil may exert deleterious effects on legume-*Rhizobium* symbiosis, either as a whole or on the micro-or macrosymbiotic component.

There is a need therefore for a proper evaluation of the herbicide effect on the symbiotic process in tropical soils. For instance, the work of Newman and Downing (11) showed that 2.4-dichlorophenoxy-acetic acid inhibited nodulation through inhibition of the growth and functions of the symbionts, that is, the legume host and the *Rhizobium* sp.

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Hence, this report is part of a study designed to evaluate the effects of some of the commonly used herbicides in Nigeria on *Rhizobium* legume symbiosis.

Materials and methods

Rhizobium strains

Two *Rhizobium* strains were used for inoculation in this study. The first strain, TAL 385, was a cowpea *Rhizobium* from Hawaii. The second was isolated from nodules of cowpea [*Vigna unguiculata* (L.) Walp. c.v. Ife Brown] at the University of Ife, and is referred to as the IFB isolate. The laboratory infectivity tests on both of them showed very positive results. The organisms were grown on Mannitol Yeast Extract Agar slants which were made up of mannitol (10 g), K_2HPO_4 (0.5 g), $MgSO_4$.-$7H_2O$(0.2 g), NaCl (0.1 g), $CaCO_3$ (3 g), yeast extract (10 g), agar (15 g) distilled H_2O (1 liter). Before use, the organisms were harvested with 10% sucrose and grown on Mannitol Yeast Extract broth on a rotatory shaker.

Herbicide formulations

The three herbicides used in this study, namely Dacthal (WP 75% active ingredients), Dual in form of an emulsifiable concentrate (500 g active ingredients/liter) and Preforan, an emulsifiable concentrate (30% active ingredients), were obtained from National Cereals Research Institute, Ibadan, where they are being constantly used for weed control in plantations of legume and legume-maize crop mixtures. For this investigation Preforan was applied at the rates of 0.4 and 8 kg a i/ha which were denoted as H_0, H_1 and H_2, respectively. Similarly, Dacthal was applied at the rates of 0, 5 and 10 kg a i/ha while Dual was used at the rates of 0, 0.5 and 1.0 kg a i/ha. Earlier in the study, the recommended rates of 2 and 4 kg a i/ha for Dual killed cowpea seedlings before 14 days after planting and therefore had to be scaled down to the rates of 0.5 and 1.0 kg a i/ha.

The sand used in these experiments was white sand obtained from the Bar Beach, Lagos. To remove organic materials and other foreign matter, the sand was washed, using several changes of 0.5 N H_2SO_4 and then neutralized by washing with NaOH solution. Thereafter, the bulk sand sample was rinsed in several changes of distilled water and then spread to dry after which it was sterilized at 1.1 kg/cm^2 pressure for 24 hours. Five kilograms of the sterile sand was then used to fill 5-liter plastic buckets which had been surface sterilized with ethanol. The basally perforated buckets were plugged with cotton wool to allow for adequate drainage.

The cowpea variety used in this investigation was *Vigna unguiculata* (L.) Walp. c.v. Ife brown which is an upright cowpea variety bred at the Faculty of Agriculture, University of Ife, Ile – Ife, Nigeria. A thick slurry of a 3-day old culture (TAL 385) mixed with bagasse and some quantity of gum arabic was used to inoculate the seeds at planting.

Starter nitrogen at the rate of 18 ppm N as ammonium sulfate was added to those treatments requiring the addition with or without inoculation. These treatment combinations resulted in a $3^2 \times 2^2$ factorial experimental design. The pots were arranged on the greenhouse bench using a split plot design with 5 replications. The different herbicide formulations were then applied with the aid of a pipette to the surface of the sand immediately after the seeds were planted.

Ten days after seed planting, a second inoculation prepared as before, was carried out to ensure a high population of the organism in the rhizosphere of the germinating legume. Watering was done with Jensen's (9) N-free nutrient solution. However, about the third week after planting, the plants appeared stunted in growth. Thereafter, the watering was reduced to twice weekly with the nutrient solution and deionized, distilled water was used in between.

The average night and day temperatures of the greenhouse during the period of the investigation were 26°C and 31°C respectively.

At 68 days after planting which coincided with initiation of flowering, each plant was carefully uprooted from the sand and the roots were rinsed in running tap water. The nodules were counted. The whole plants were packed into paper bags and dried in a forced air oven at 80°C for 48 hours. After cooling, the dry matter weights were determined. The nitrogen content of weighed samples was determined by an autoanalyser after digestion of the plant tissues with concentrated sulfuric acid.

Results and discussion

A slight reduction in rootlet development was observed in the Ife Brown cowpea variety whose seeds were inoculated with TAL 385 impregnated into bagasse which was used as the *Rhizobium* carrier. This reduction in root growth was suspected to be due to charring by bagasse and the gum arabic. The root crown was also partly burnt. The significance of this observation is that the plants would probably be deprived of some infection sites for the *Rhizobium* (7, 11).

However, the stimulatory role of starter N (18 ppm) was evident in the generally more luxuriant growth of those plants that received the starter N compared to those that did not. A similar trend was also observed in the degree of nodulation and dry matter yield of plants that were inoculated and received starter N compared to those inoculated but without starter N, irrespective of the type and rate of herbicide application (Figure 1). The mean dry matter weight of plants to which starter N with inoculation was applied was 117 mg/plant compared to 66.2 mg with inoculation but no starter N.

When the herbicide rates and types are considered, results of analysis indicate that it is the herbicide type rather than the rate that has a significant effect ($P \leq 0.01$) on nodulation.

The plants that were treated with either Dacthal or Preforan had significantly higher nodule dry matter weight per plant compared to those that were treated with Dual (Table 1). This significant reduction could be due to the fact that Dual inhibited the root growth and further reduced the root size of the legume plants which had already been slightly charred by the *Rhizobium* carrier used for inoculation. The degree of nodulation is known to correlate closely with the number of infection sites available on the root system (5, 7, 11). This significant reduction in nodule dry weight of plants treated with Dual relative to the other two herbicides agrees with results using agar culture where it was found that Dual inhibited significantly the growth of this *Rhizobium* sp. compared to the other herbicides (3).

As shown in Figure 2, starter N boosted very significantly ($P \leq 0.01$) the total N accumulation in the cowpea plants which were inoculated. This is consistent and shows a very high correlation ($r = 0.96$) between total N and dry matter accumulation when starter N was applied, irrespective of the type and rate of herbicide applied. This is not a peculiar observation because Agboola (1) amongst others, had demonstrated a straight linear relationship between dry matter weight and total N of legumes. However, the herbicide type influenced very significantly the total N of the inoculated cowpeas (Table 1). The significantly higher total N ($P \leq 0.01$) under Dacthal and Preforan treatment compared to Dual is again probably explained by the phytotoxicity of Dual to the legume roots. This trend in total N was also found to be consistent with N fixed. Application of Dual significantly ($P \leq 0.01$) reduced the amount of nitrogen fixed, when compared to either Dacthal or Preforan. This behaviour of Dual with regard to the nitrogen fixed

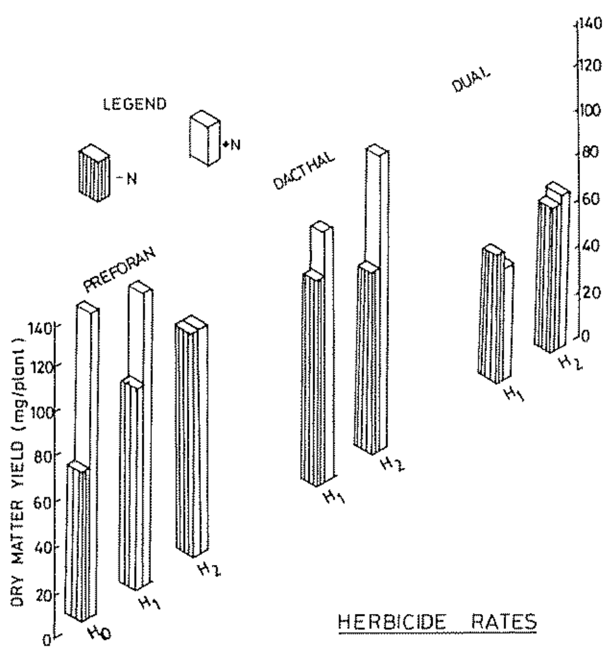

Fig. 1 Effect of herbicide type and rate on dry matter yield of Ife Brown cowpea (*Vigna unguiculata* L. Walp.) inoculated with *Rhizobium* sp. and with or without stater N.

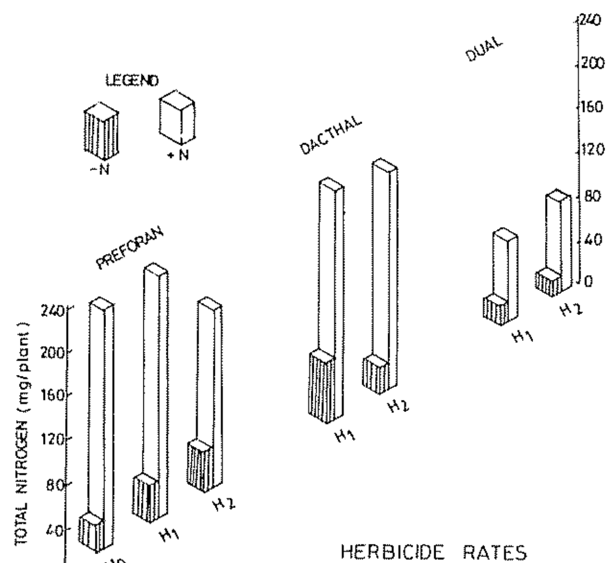

Fig. 2. Effect of herbicide type and rate on total nitrogen of cowpea (*Vigna unguiculata* L. Walp.) var. Ife Brown inoculated with *Rhizobium* sp. with or without starter N.

Table 1. Effect of herbicide type on nitrogen fixation by Ife brown inoculated with TAL 385 *Rhizobium* sp. and with added stater N.

Variable	Preforan	Dacthal	Dual	DMR+
Nodule dry wt mg/plant	3 50[b]	3 75[b]	1 56[a]	1 94*
Nitrogen fixed (%)	0 35[b]	0.42[b]	0.27[a]	0 13*
Total Nitrogen mg/plant	114.86[b]	113 08[b]	67 75[a]	40.68**

\+ Duncan Multiple Range test. Numbers followed by the same letter are not significantly different from each other.

* Significant at $P \leq 0.05$

** Significant at $P \leq 0.01$

would agree with the reductions in plant vegetative growth and nodulation earlier referred to.

Because of the charring of roots suspected to be caused by the gum arabic and bagasse used as the inoculant carrier, another experiment was set up as before but with a few modifications. Instead of TAL 385 strain of *Rhizobium* sp, IFB isolate was used as a thick slurry instead of being impregnated into a carrier. All the treatments received 18 ppm N as starter nitrogen since it was found to boost plant growth. Apart from these few modifications, the experimental details were as before.

Results indicate theat Dual treatment of plants significantly ($P \leq 0.01$) depressed nodule formation when compared to Dacthal and Preforan (Table 2). This depression of nodulation might be a manifestation of inhibition of root development as known to be common with the amide group of herbicides (6). The inhibition by Dual is probably more of a phytotoxic effect than the effect of the herbicide on the *Rhizobium per se*, since in agar culture there was no significant inhibition of this strain of *Rhizobium* Daethal or Dual. As noted earlier, it is possible that the reduction in total N fixed in plants treated with Preforan is a manifestation of Preforan inhibition

Table 2. Effect of herbicide type and rate on dry matter yield and nitrogen fixation in Ife brown inoculated with IFB isolate.

Herbicide type	Herbicide rate	Dry matter[1] g/plant	Nitrogen fixed[2] g/100 g plant
None	H_0	0 68[a]	0 76[a]
Preforan	H_1	0.49[b]	0 15[bc]
	H_2	0.46[b]	0.11[cd]
Dacthal	H_1	0.54[ab]	0.22[b]
	H_2	0.69[a]	0.77[a]
Dual	H_1	0 27[c]	0.07[d]
	H_2	0 18[c]	0 08[d]

1 LSD = 0.17, numbers followed by same letter are not significantly different from one another.

2 LSD = 0.07, numbers followed by same letter are not significantly different from one another.

by Dual (3). In the case of Preforan, it is possible that the microbial toxicity exhibited in agar culture is also exhibited in the sand culture, although to a reduced degree. However, in all the treatments, the application of the highest rate (H_2) of the herbicides significantly depressed ($P \leq 0.01$) nodulation when compared to the H_0 treatment, whereas the H_1 depression rate was only significant at 5 percent.

In terms of dry matter yield, the herbicide type also becomes important (Table 2). Plants treated with Dacthal had significantly ($P \leq 0.01$) higher dry matter accumulation when compared to either Preforan or Dual treatments. A similar stimulatory action of Dacthal on dry matter accumulation in horticultural crops had earlier been reported by Iyer (8). With respect to the total amount of N fixed, Table 2 also indicates that nitrogen fixation was significantly impaired when the plants treated with Dual were compared with those treated with Dacthal, but there was no difference when the effect of Preforan was compared with either of agar culture of this *Rhizobium* sp. (3). The higher dry matter accumulation induced by Dacthal and Preforan is also reflected in the higher amount of N fixed by plant under these herbicide treatments.

On the basis of these results, it is recommended that the use of Dual as a herbicide for weed control in legume production should be discouraged. The other two herbicides, namely Dacthal and Preforan, should be used only at the recommended rates of 5 and 4 kg a i/ha for effective weed control in legume crop production. Also efforts should be geared towards finding a suitable *Rhizobium* carrier for use in the tropics.

Summary

In a first experiment, application of Dual to the seeds of Ife Brown in sand culture inoculated with TAL 385 strain of *Rhizobium* depressed nodulation, and reduced the amount of nitrogen fixed significantly when compared with either Dacthal or Preforan. Addition of starter N to the inoculated seeds boosted dry matter yield and percent nitrogen when compared to those without starter N.

In a second trial, application of Dual to Ife Brown inoculated with IFB isolate also significantly depressed nodulation, reduced dry matter yield and nitrogen fixation of the legume when compared with Dacthal treatment and non-significantly when compared with Preforan.

Based on these findings, it is suggested that in legume production either Dacthal or Preforan should be used preferentially to Dual. Also applying the intermediate rates (H_1) of the herbicides effectively controlled weeds and did not have the deleterious effects on the vital parameters of nitrogen fixation as the H_2 rates.

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UTILIZACION DE ISOENZIMAS COMO MARCADORES GENETICOS EN *Saccharum*[1] /

*ADELAIDA BARRETO**
*JEAN–PIERRE SIMON***

Summary

A study was done of the use of electrophoretic technique on polyacrylamide gel for the identification of varieties and for recognizing hybrid progenies in Saccharum. *The isoenzymatic patterns were characterized by peroxidases and esterases in nineteen varieties of sugar cane. It was shown possible to distinguish the zymograms of the two systems, given the existing inter-varietal variation, and thus the method may be used as a means of identification. An analysis was done of the* S. officinarum *(female progenitor)* S. spontaneum *(male progenitor) cross; and of* S. officinarum S. robustum *(male parent) The parental band complementarity in the hybrid offspring could provide a possible means of determining the real male progenitor, so long as the maternal material is has a smaller number of bands than the paternal material.*

Introducción

Los estudios bioquímicos han adquirido recientemente una gran importancia en el campo de la genética. El hallazgo de nuevos métodos aplicables al mejoramiento de plantas ha brindado un apoyo apreciable a los investigadores de este campo.

Las técnicas electroforéticas basadas en la variabilidad existente, para una forma enzimática dada, con relación al peso molecular y a la carga eléctrica, y el mantenimiento de su actividad catalítica, han permitido la confección de patrones isoenzimáticos utilizables en la identificación varietal y en la determinación de las bandas parentales en la progenie híbrida (Gottlieb 6); Ayala (2).

Los métodos de mejora en caña de azúcar necesitan de pruebas de progenie para el análisis de la habilidad combinatoria de los padres. Los mejoradores de caña están interesados en buscar métodos apropiados para determinar con certeza el origen del progenitor masculino de los híbridos que sean posteriormente seleccionados (Iglesias *et al.* 8).

El alto grado de poliploidía existente en *Saccharum* implica que cualquier caracter que desee usarse como marcador genético, no sea heredado en forma dominante, sino que su expresión en el híbrido sea cuantitativa, lo que indicaría poca expresividad y penetración (Price 13); Lewis (10).

El uso de múltiples formas moleculares de enzimas, o isoenzimas, brindan una vía posible de obtener marcadores bioquímicos que faciliten la interpretación y el reconocimiento de híbridos intervarietales o interespecíficos (Lewontin 11); (Johnson 9); Lewis (10). Recientemente se han reportado dos trabajos que indican la probable utilización de isoenzimas para reconocer variedades e identificar cruzamientos entre distintas variedades y especies del género *Saccharum*

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Agradecemos la colaboración de Martha Alvarez y Sonia Xiqués, alumnas de 4to. y 3er. año de la Escuela de Ciencias Biológicas, Universidad de La Habana, prestada durante el desarrollo de esta investigación. Se agradece también la ayuda brindada por el Ing. Mario Amador al facilitarnos las variedades de caña de azúcar con las cuales trabajamos

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(Thom y Naretzki 19); Waldron y Glasziou 20) y para estudiar los procesos evolutivos y relaciones filogenéticas de los géneros afines a *Saccharum* Rougham *et al.* (15); Waldron *et al.* (21). Estudios citogenéticos correlacionados con este trabajo han sido realizados por Barreto y Simon (3).

Materiales y métodos

Se estudiaron 19 variedades de caña de azúcar, representantes de las especies de *Saccharum*, conjuntamente con algunos híbridos simples y complejos. Este material ya había sido analizado citológicamente por Barreto y Simon (3).

La obtención de las muestras se realizó a partir de los trozos de caña de una sola yema, los cuales germinaron en recipientes adecuados a una temperatura ambiente de 25°C. Las yemas de 1.5 a 2 cm se cortaron, clasificaron por variedad, y colocaron en el congelador a −15°C, hasta el momento de hacer los extractos.

De cada variedad se tomaron varias yemas (0.2 g) a las cuales se agregó 200 µl de una solución de sacarosa al 20%. Las muestras se maceraron en un mortero frio y el producto obtenido se transfirió sobre una pieza pequeña de gasa, la cual se exprimió, y el extracto se vertió sobre una placa horadada.

Varias soluciones fueron utilizadas para la extracción, tales como fosfato, Tris-HCl glicina-HCl, soluciones de glucosa a varias concentraciones, ácido ascórbico, y/o 2-mercaptoetanol (0.1-2%). Se optó por estandarizar el procedimiento de extracción con una solución de sacarosa al 20% al no observarse diferencias significativas con los resultados.

La electroforesis se llevó a cabo en un sistema de tampones discontinuo y gel de acrilamida, usado para la electroforesis de disco por Ornstein (12) y Davis (5), y adaptado a la técnica de lámina (slab) vertical (Simon 16, 17; Chapel *et al.* 12). El gel de compactación se preparó con una concentración del 5% Cyanogum-41* en un tampon Tris-HCl 0.1 M, pH 6.7, y el gel de separación con un 9% y 12.5% Cyanogum 41* para isoenzimas peroxidasas y esterasas repectivamente, en buffer Tris-HC1, 0.5 M, pH 8.9. El buffer Tris-glicina 0.04 M, pH 8.3, se empleó en los compartimentos de los electrodos, al cual se le agregó 10 µl de una solución de bromo-fenol azul para marcar con más precisión la banda de Kohlrausch. Se usó un aparato de electroforesis vertical construido por los autores (Chapel *et al.* 12) y simplificado del descrito por Raymond (14).

El tiempo de corrida para la peroxidadas fue de 2.5 a 3 horas de 40 ma y de 4.5 a 5 horas a 30 ma para las esterasas.

La tinción para las isoenzimas de peroxidasas se logró con una solución de 2 g de benzidina di-hidroclórica, disueltos en 14 ml de ácido acético glacial, aforada a 100 ml con agua destilada. Una solución de agua oxigenada (11 volumenes) al 33% se mezcló con la anterior al momento de la tinción.

El gel se tiñó durante 1-4 minutos en la mezcla preparada; luego se lavó y mantuvo en una solución al 9% de ácido acético glacial. El gel de esterasas se incubó en una solución de ácido bórico 0.5 M, por 1 hora a 5°C (Simon 17), y posteriormente los perfiles isoenzimáticos se obtuvieron al colocar el gel en una solución de 100 ml de solución tampón fosfato, 01. M, pH 6.4, con 2 ml de α-napthyl acetato (1 g de α-napthyl acetato en 1:1, acetona-agua destilada, para 100 ml de solución; 2 ml de una solución de β-napthyl acetato (0.3 g de β-napthyl acetato en 1:1, acetona-agua destilada, para 30 ml de solución) y 200 mg de Fast Blue RR.

Los patrones de bandas peroxidasas y esterasas se dibujaron sobre papel milimetrado, designando como 0 el punto de unión del gel de compactación y separación, y como 100 la situación de la banda 1, la más rápida de la migración anódica.

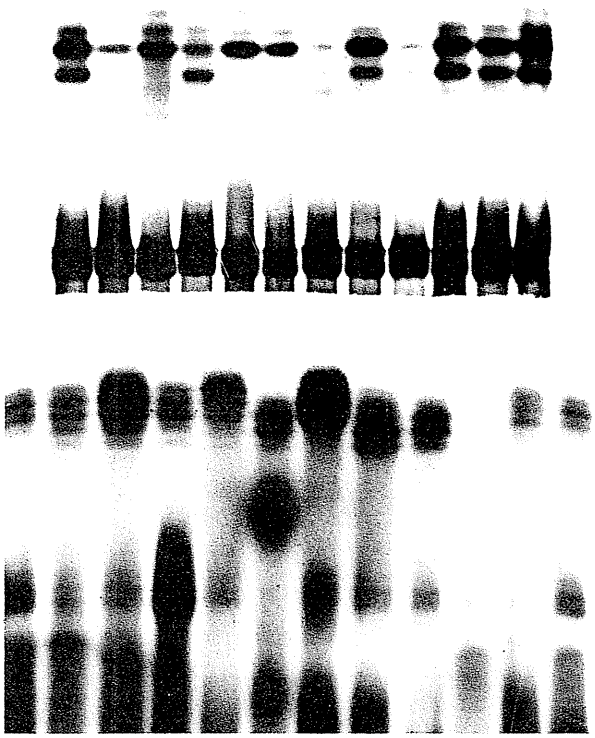
Algunos geles representativos se fotografiaron utilizando el sistema Taucoli, de la ampliadora Durtz, como fuente de contraluz y negativos Panatomic X (blanco y negro), y ORWO CHROMOUT 18 (Placas Y1; Y2), para color.

Resultados y discusión

Patrones isoenzimáticos de especies de *Saccharum*

Los análisis isoenzimáticos realizados en *Saccharum* determinaron la confección de los zimogramas correspondientes de las isoenzimas peroxidasas y esterasas para variedades de las cinco especies (Figuras 1 y 2). Estos se basaron fundamentalmente en el estudio de la zona de bandas más claras y definidas, situada más cerca de la región anódica (+). Las zonas más difusas y semejantes para la mayoría de las variedades, presentes en la zona superior del gel, no fueron consideradas.

* British Drug House, Inglaterra.



Placa. Electroforesis en gel de acrilamida de isoenzimas peroxidasas (A) y esterasas (B) en variedades de caña de azúcar.

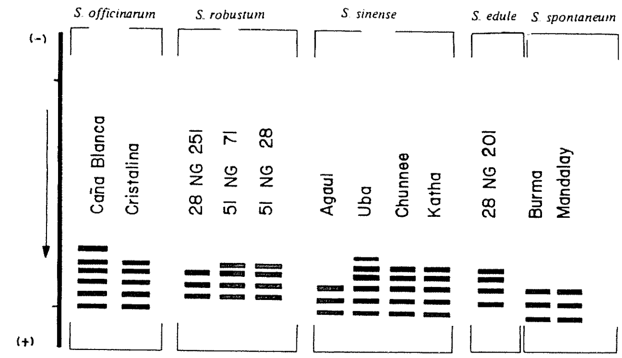


Fig. 1. Zimograma de isoenzimas peroxidasa en 12 variedades de las cinco especies del género *Saccharum*.

Los patrones de peroxidasas demostraron la existencia de tres bandas comunes (3-4-5), en las variedades estudiadas, las cuales podrían referirse como características del género; en el caso de las esterasas se presentan las bandas 2 y 3 como típicas de los perfiles de esta enzima. La afinidad planteada para ciertas bandas de peroxidasas y esterasas no implica una falta de variabilidad ya que la presencia de otras permite apreciar la diferenciación intervarietal.

A pesar de la similitud existente en las determinaciones de cada banda para algunas variedades, con relación a una isoenzima determinada, al realizar la comparación para peroxidasas y esterasas conjuntamente, se establecen patrones diferentes que permiten la utilización de este método en la identificación de clones de caña de azúcar.

Se presenta una coincidencia estrecha para ambas isoenzimas en las variedades Chunnee y Katha de la especie *S. sinense* y en los clones Burma y Mandalay de la especie *S. spontaneum*. Por esta razón, en situaciones similares los estudios isoenzimáticos se deben basar en un número mayor de enzimas para lograr la diferenciación necesaria en la caracterización.

Waldron y Glasziou (20), trabajaron con isoenzimas peroxidasas y esterasas en caña de azúcar, empleando la técnica de geles con gradientes de concentración de poliacrilamida, empleando variedades comunes a las referidas en este trabajo. Los patrones esterasas de los clones 28 NG 251, Chunnee y Uba concuerdan en ambas investigaciones, mientras que en el caso de Mandalay y Burma difieren en una y dos bandas, respectivamente.

Complementación en híbridos interespecíficos

La presencia de bandas isoenzimáticas distintivas en los padres que intervienen en un cruzamiento específico permite observar el fenómeno de complementación de dichas bandas en la progenie híbrida.

Los cruzamientos interespecíficos de este trabajo implican las especies *S. officinarum*, como parental femenino, X *S. spontaneum*, como parental masculino.

La variedad Caña Blanca (*S. officinarum*) utilizada en cruzamiento con las variedades Burna y Mandalay (*S. spontaneum*), presenta un patrón de 6 bandas

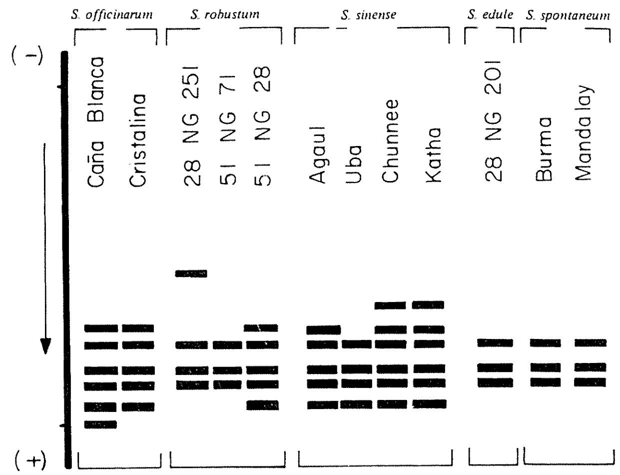


Fig. 2. Zimograma de isoenzimas esteresas en 12 variedades de las cinco especies del género *Saccharum.*

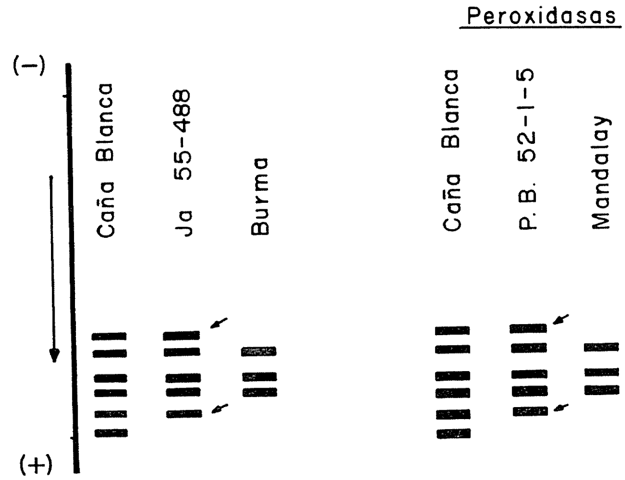


Fig. 3. Complementación de las isoenzimas parentales en híbridos interespecíficos de *S. officinarum* X *S. spontaneum* para peroxidasas. Las flechas indican las bandas complementarias maternas.

para las peroxidasas, siendo la primera la más rápida en migración al polo positivo (ánodo). Las variedades de *S. spontaneum,* muestran solamente las bandas 3-4-5. Los híbridos Ja 55-488 y PB 52-1-5, llevan las bandas de ambos padres, excepto la 1, perteneciente al progenitor femenino (Figura 3).

Los patrones de esterasas observados en Caña Blanca consisten de 6 bandas, mientras que en las variedades Burma y Mandalay solo se encuentran las bandas 1-2-3. La progenie híbrida del primer cruce (Ja 55-488), presenta las bandas 1-2-3-4-5, con la ausencia de la 6 perteneciente al parental femenino. El híbrido del segundo cruce (PB 52-1-5), posee las bandas 1-2-3-4, faltándole las 5 y 6 (Figura 4).

Waldron y Glasziou (20), mostraron la presencia de algunas o todas las bandas isoenzimáticas parentales características de una región determinada en las progenies híbridas de los cruces estudiados *S. officinarum* X *S. spontaneum.*

La complementación de bandas parentales en los híbridos de caña de azúcar será válida siempre que parta de material materno con patrones isoenzimáticos de un número menor de bandas, o que existan bandas distintas en los clones usados como progenitores masculinos con relación a dicho material. De los contrario, podría caerse en un error al plantear como híbrido un producto de autofecundación.

Análisis isoenzimáticos de un cruce *S. officinarum* X S. robustum y su autofecundación

Los estudios isoenzimáticos llevados a cabo en este trabajo para el híbrido simple C.P. 36-138 y sus

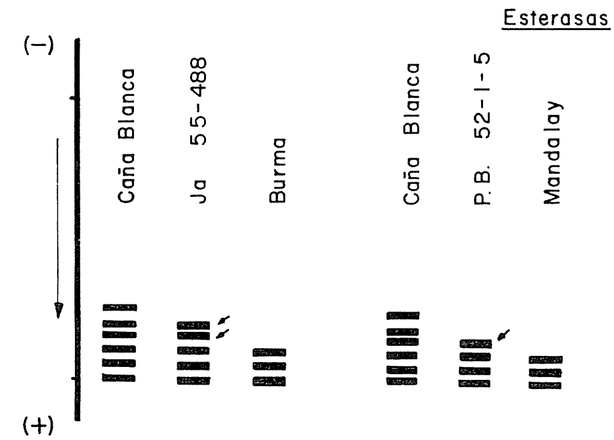


Fig. 4. Complementación de las isoenzimas parentales en híbridos interespecíficos de *S. officinarum* X *S. spontaneum* para esterasas. Las flechas indican las bandas complementarias maternas.

progenitores, muestran la no complementación de una banda parental diferencial perteneciente al patrón del supuesto progenitor masculino para isoenzimas peroxidasas (Figura 5). El perfil de esterasas presenta las bandas 2-3-4-5, siendo esta última característica del parental femenino (Figura 6).

La autofecundación My 53205 muestra las bandas de peroxidasas 2-3-4-5-6 típicas de C.P. 36-138 y la banda 7 única de este clon, mientras que en el patrón de esterasas está ausente la banda 2, presente en C.P. 36-138 (Figuras 5 y 6).

La comparación de los patrones isoenzimáticos de C.P. 36-138 con la de sus supuestos progenitores

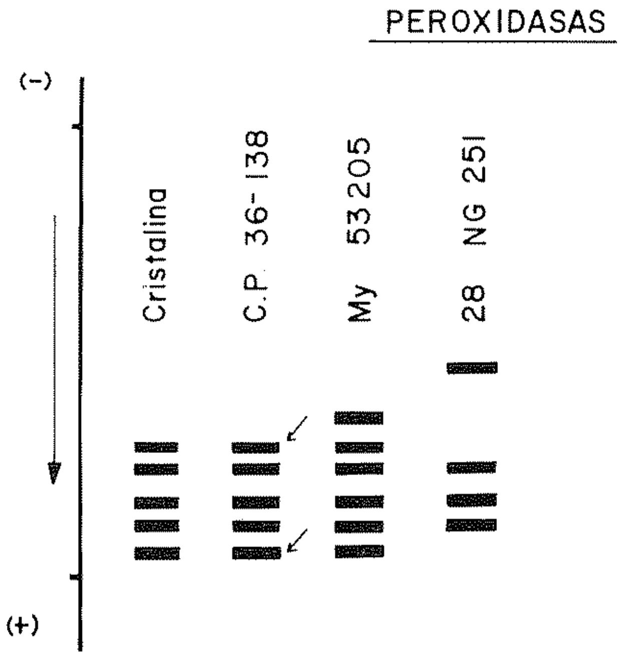


Fig 5. Zimograma de un cruce *S. officinarum* X *S. robustum* y autofecundación. Las fechas señalan las bandas peroxidasas provenientes del progenitor femenino presentes en el híbrido.

plantea, al igual que los análisis citogenéticos (Price 13; Barreto y Simon 3), un origen dudoso para este clon. Sin embargo, cabe recordar que el grado de heterocigosis en variedades de caña de azúcar es alto y la no complementación observada en los patrones enzimáticos de C.P. 36-138 puede deberse también a la expresión génica del proceso de recombinación.

Si bien es cierto, este proceso no incide tanto en la variabilidad de poliploides, ésta puede expresarse si el producto es entre variedades de origen híbrido de alto grado de heterocigosis (Stebbins 18; Lewis 10). La variedad C.P. 36-138 reúne estas características ya que su origen es probablemente el resultado de un cruzamiento interespecífico. Una explicación similar puede proponerse para explicar las diferencias entre los patrones isoenzimáticos C.P. 36-138 y su autofecundación My 53205. En este caso, al autofecundar un clon altamente heterocigoto como el C.P. 36-138, se producirá una progenie variable debido al proceso de recombinación operante. Cabe recordar que estudios citogenéticos (Barreto y Simon 3) han demostrado que la My 53205 posee un número de cromosomas menor que la C.P. 36-138, por lo que es posible que la pérdida de bandas observadas en los patrones isoenzimáticos de My 53205 sean en parte un reflejo de la aneuploidía en el complemento de este clon autofecundado.

Lo planteado para la C. P. 36-138, conjuntamente con el hecho de la aparición de una banda de peroxidasas, hallada solamente en My 53205 y la ausencia de la banda 2 de esterasas con relación a su progenitor C. P. 36-138, debe llevar a un estudio más profundo de estas variedades, fundamentando el análisis en sistemas isoenzimáticos adicionales.

Isoenzimas peroxidasas y esterasas en híbridos complejos

Los patrones de isoenzimas peroxidasas y esterasas de los híbridos complejos analizados se muestran en la Figura 7.

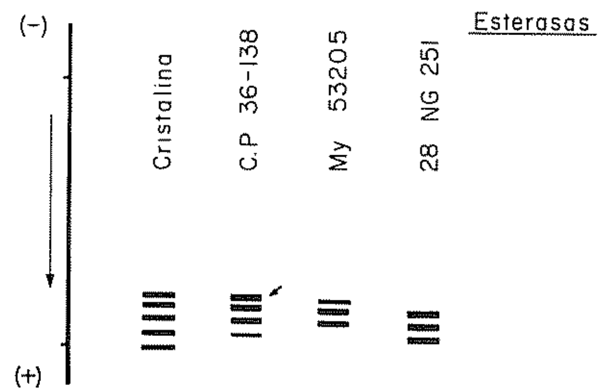


Fig. 6. Zimograma de un cruce *S. officinarum* X *S. robustum* y su autofecundación. Las fechas señalan las bandas esterasas provenientes del progenitor femenino presente en el híbrido.

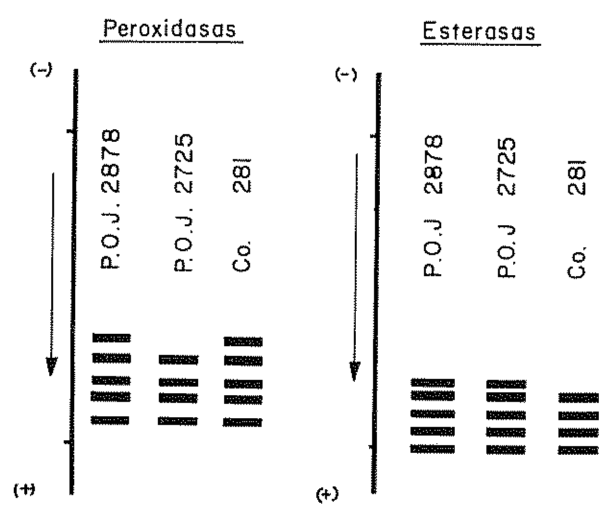


Fig. 7. Patrones de isoenzimas peroxidasas y esterasas en híbridos complejos.

Los perfiles de peroxidasas muestran semejanza en la P.O.J. 2878 y en la Co. 281 para las bandas 2-3-4-5 y 6; lo mismo sucede para las esterasas en los clones híbridos P.O.J. 2878 y P.O.J. 2725, llevando las bandas 1-2-3-4-5. La ocurrencia de un mismo patrón isoenzimático, respecto a una isoenzima particular, no inválida la utilización de esta técnica electroforética como una forma posible de identificación de híbridos. La caracterización de isoenzimas distintas permite determinar la diferenciación de dichos materiales.

La electroforesis en gel de acrilamida puede considerarse como un medio más al alcance de los mejoradores de caña de azúcar. El uso de formas moleculares múltiples de una enzima, se ha probado como válido para la identificación de variedades de caña, pues las diferencias intervarietales han sido detectadas a niveles isoenzimáticos para los patrones de peroxidasas y esterasas. El análisis de un número mayor de enzimas ayudaría a una mejor determinación varietal sobre todo en aquellos casos en que pueda existir coincidencia de perfiles.

Los problemas que pueden presentarse con relación a los cruzamientos programados y las progenies híbridas obtenidas, ven como una solución posible la caracterización de los híbridos a partir de sus patrones isoenzimáticos. La probable contaminación con polen extraño puede determinarse mediante los análisis electroforéticos y la incidencia de bandas parentales en el perfil de híbridos; esto facilita al mejorador eliminar aquel material no requerido.

En *Saccharum*, la complementación de bandas de isoenzimas será muy útil siempre que se parta de material parental masculino con un número mayor de bandas, o bandas diferenciales, respecto al progenitor femenino. Los cruces interespecíficos analizados en este trabajo, *S. officinarum* X *S. spontaneum*, *S. officinarum* X *S. robustum*, en los cuales el parental femenino es siempre la especie *S. officinarum* no permiten una verdadera apreciación de este fenómeno, dada la cantidad mayor de bandas que posee ésta comparada con las otras especies.

La posibilidad de expresión del fenómeno de recombinación al nivel isoenzimático en material alopoliploide segmental, debe tenerse en cuenta en el problema de la complementación (Stebbins 18); Lewis (10), pues puede manifestarse en la presencia o ausencia de algunas de las bandas parentales en la progenie híbrida. El análisis del material híbrido complejo implica la posibilidad de poder utilizar esta técnica como un índice de caracterización de progenies provenientes de cruces intervarietales, siempre que se utilice más de un sistema isoenzimático. La determinación de progenies híbridas a un nivel isoenzimático brinda un medio más rápido y eficiente que aquella basada en el conteo de cromosomas, debido a los problemas a nivel citogenético que presenta el género *Saccharum*.

Resumen

Se realizó un estudio de la aplicación de las técnicas electroforéticas en gel de poliacrilamida para la identificación varietal y el reconocimiento de las progenies híbridas en *Saccharum*. Los patrones isoenzimáticos fueron caracterizados para peroxidasas y esterasas en 19 variedades de caña de azúcar. Se obtuvo diferenciación de los zimogramas de ambos sistemas, dada la variación intervarietal existente, lo que permite la utilización del método como un medio de identificación. Se hicieron análisis de los cruzamientos *S. officinarum* (progenitor femenino) X *S. spontaneum* (progenitor masculino); y *S. officinarum* X *S. robustum* (parental masculino). La complementación de bandas parentales en la progenie híbrida puede servir como una vía posible de determinación del progenitor masculino real, siempre que parta de material materno con un número menor de bandas con relación al material paterno.

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CONTENIDO

'MONROE' BEAN (*Phaseolus vulgaris*): A LOCAL LESION ASSAY VARIETY FOR BEAN COMMON MOSAIC AND SOYBEAN MOSAIC VIRUSES[1] /

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*PABLO J. TAMAYO M.**
*FRANCISCO J. MORALES G.***

Resumen

*La variedad de frijol (*Phaseolus vulgaris *L.) 'Monroe', recomendada como planta indicadora de lesiones locales para el virus del mosaico común del frijol (BCMV), reaccionó con lesiones locales necróticas de forma anillada, tanto a la inoculación de cinco cepas diferentes del BCMV como a cinco aislamientos del virus del mosaico de la soya (SMV). Las condiciones ambientales bajo las cuales se realizaron estas pruebas tuvieron un efecto marcado sobre la aparición y desarrollo de las lesiones locales necróticas anilladas especialmente en el caso del SMV.*

Introduction

The bean (*Phaseolus vulgaris* L.) variety 'Monroe' has been used as a local lesion assay plant for bean common mosaic virus (BCMV) since 1971 (3, 5, 6). The local lesions observed on the primary leaves of mechanically-inoculated plants vary from the typical necrotic type to the ringspot pattern. Trujillo and Saettler (5) found that lesions were of the local necrotic type under normal glasshouse light conditions and temperatures between 16°C and 20°C, whereas following a 24 h pre-inoculation darkness period and at temperature between 24°C and 28°C, lesions were of the ringspot type.

Since Topcrop another bean variety recommended for local lesion assay of soybean mosaic virus (SMV) (1), is known to show a similar necrotic reaction when inoculated with BCMV (2), this study was conducted to determine whether 'Monroe' can be recommended as a diagnostic species for BCMV using various BCMV strains and SMV isolates.

Materials and methods

Five strains of BCMV maintained and characterized at the International Centre for Tropical Agriculture (CIAT), Palmira, Colombia, as the Type, Florida (FLA), New York 15 (NY 15), NL-3 and NL-4 strains of BCMV, and five local isolates of SMV were chosen for this study. The viruses, BCMV and SMV, were maintained in susceptible bean or soybean varieties, respectively. The identity of the SMV isolates, originally isolated from seed-infected soybean plants, was confirmed through infectivity and serological tests.

The inoculum consisted of systemically-infected primary and/or first trifoliate leaves of 22 day-old bean (for BCMV) or soybean (for SMV) plants. Plant extracts were prepared with the aid of pestle and mortars in 0.01 M potassium phosphate buffer, pH 7.5 until a 1:10 (W/V) dilution was reached. The inoculum was rubbed onto the primary leaves of 8-9 day-old 'Monroe' bean seedlings using a sterile cheesecloth pad. The inoculated seedlings were placed under two different environmental conditions: a glasshouse

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with a 19°C-28°C temperature range and a growth room with a mean temperature between 16°C-19°C and 12 500 lux eight hours a day.

A group of 'Monroe' seedlings was also kept in total darkness for 24 hours before the inoculation and, subsequently, placed under the two environmental regimes described above, following their inoculation.

Results

Four to five days after inoculation with the BCMV strains, the test plants maintained in the glasshouse, both with and without the pre-inoculation darkness treatment, began to show chlorotic lesions on the inoculated leaves, which developed into the typical brown ring-shaped lesions (Table 1) described for BCMV on 'Monroe' (5). Each of the five BCMV strains induced the same reaction on 'Monroe' (Figure 1, A-E). The pre-inoculation darkness treatment resulted in the appearance of well defined ring-shaped local lesions as early as four days after inoculation.

There were appreciable differences in symptom expression between the glasshouse and growth room-grown test plants. In the growth room only those seedlings inoculated with the Type strain of BCMV and which had been held in the dark before inoculation, showed necrotic local lesions and vein necrosis six days after inoculation (Table 1). The rest of the inoculated test plants showed ring-shaped lesions 15 days after inoculation with the other four BCMV strains.

The SMV-inoculated 'Monroe' plants maintained in the glasshouse, with or without the pre-inoculation darkness period, exhibited chlorotic lesions on the inoculated leaves 5 to 7 days following inoculation. Within 10 days, these lesions had also developed into the typical brown ringshaped lesions (Figure 1, F) described for BCMV on this bean variety (Table 2). The lesions induced by SMV on 'Monroe' were more abundant and defined than those observed for any of the five BCMV strains tested.

The 'Monroe' plants previously held in the dark and then placed in the growth room, also showed the characteristic ring-shaped local lesions seven days after inoculation (Table 2). Those SMV-inoculated test plants which had not been held in the dark prior to their inoculation took two weeks to show the ring-shaped local lesions. These reactions were observed with the five SMV isolates tested.

Discussion

The results obtained in this study clearly demonstrate that the bean variety 'Monroe' cannot be recommended as a diagnostic or local lesion assay plant exclusively for BCMV, since this variety proved here to react with local ring-shape lesions to a related but different virus, SMV.

Table 1. Local lesion development on the primary leaves of 'Monroe' bean plants inoculated with five strains of bean common mosaic virus under two environmental conditions and pre-inoculation treatments.

BCMV Strain	Without pre-inoculation darkness treatment				With pre-inoculation darkness treatment			
	I		II		I		II	
	GH[1]	GR	GH	GR	GH	GR	GH	GR
Type	2/4[2]	0/4	4/4	0/4	4/4	4/4[3]	4/4	2/4[3]
Florida	4/4	0/4	4/4	0/4	4/4	0/4	4/4	0/4
New York-15	4/4	0/4	4/4	0/4	4/4	0/4	4/4	0/4
NL-3	2/4	0/4	4/4	0/4	4/4	0/4	4/4	0/4
NL-4	4/4	0/4	4/4	0/4	4/4	0/4	4/4	0/4

1 GH = glasshouse conditions (19°C-28°C); GR = growth room conditions (16°C-19°C).

2 Number of plants with local lesions over number of plants inoculated.

3 Local necrotic lesions, not of the ring-shaped type.

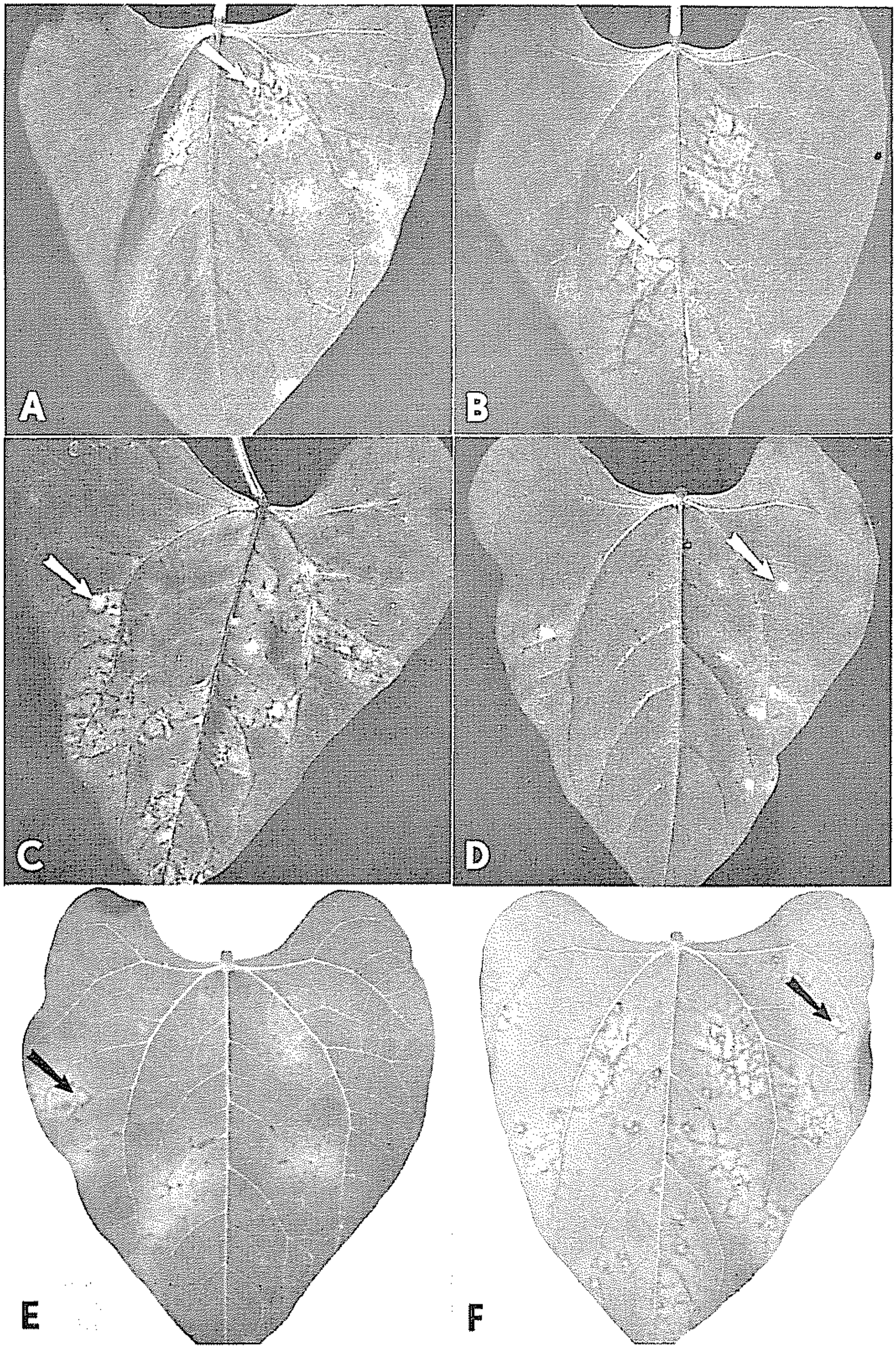

Fig. 1. Ring-shaped local lesions (shown by arrows) induced on bean 'Monroe' leaves mechanically inoculated with the: A) Type; B) NL3; C) NL4; D) New York 15; or E) Florida strain of bean common mosaic virus; and with F) a local isolate of soybean mosaic virus.

Table 2. Local lesion development on the primary leaves of 'Monroe' bean plants inoculated with five isolates of soybean mosaic virus under two environmental conditions and pre-inoculation treatments.

SMV Isolates	Without pre-inoculation darkness treatment				With pre-inoculation darkness treatment			
	I		II		I		II	
	GH[1]	GR	GH	GR	GH	GR	GH	GR
SMV-1	4/4[2]	0/4	4/4	0/4	4/4	2/4	4/4	0/4
SMV-2	2/4	0/4	2/4	0/4	4/4	3/4	4/4	3/4
SMV-3	2/4	0/4	2/4	0/4	4/4	4/4	4/4	4/4
SMV-4	4/4	0/4	2/4	0/4	4/4	2/4	4/4	0/4
SMV-5	2/4	0/4	2/4	0/4	3/4	1/4	4/4	1/4

1 GH = glasshouse conditions (19°C-28°C); GR = growth room conditions (16°C-19°C).

2 Number of plants with local ring-shaped lesions over number of plants inoculated

In agreement with previous workers, it was also shown that environmental conditions play an important role in the development of local lesions on 'Monroe' plants inoculated with either BCMV or SMV variants and that a pre-inoculation darkness treatment enhances symptom expression.

Summary

The Monroe bean (*Phaseolus vulgaris* L.), recommended as an indicator plant of local lesions for the common bean mosaic virus (BCMV), reacted with local ringed necrotic lesions, both from inoculation of five different strains of BCMV, and to five isolations of the soy mosaic virus (SMV). The environmental conditions under which these tests were done had a striking effect on the appearance and development of local ringed necrotic lesions, especially for SMV.

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COMUNICACIONES

Enterolobium cyclocarpum (Jacq.) Gris., un nuevo hospedero para *Ravenelia lagertheimiana* Diet.

Summary. This is the first record of *Ravenelia lagerheimiana* Diet. on seedlings of *Enterolobium cyclocarpum* (Jacq.) Gris. Germinated in the field and transplanted to greenhouse conditions. Pictures and descriptions of uredosori and spermogonia growing on seedling shoots are shown. The paper reports also the unpublished record of *Ravenelia havanensis* Arthur in the same host. Preliminary observations indicate that *R. lagerheimiana* can be controlled by the use of fungicides such as fermate.

El estudio de hongos patógenos del orden uredinales ha sido limitado en Centroamérica, pero han recibido mayor atención en las zonas subtropicales de Suramérica, especialmente en Venezuela (3, 4, 5, 6, 7, 8, 10, 14). En todas esas publicaciones se citan algunas especies de *Ravenelia* en hospederos de los géneros *Cassia, Indigofera, Mimosa, Pithecelobium,* todos de la familia leguminosae. Se ha informado también su presencia en euforbiáceas y tiliáceas (1). Algunas especies de ascomicetes utilizan *E. cyclocarpum* como hospedero (9, 11), así como un poliporáceo (2). Según el Dr. E. E. Leppik del Depto. de Ag. de los E. U. de A. (comunicación personal) *R. lagerheimiana* fue descrita por Dietel, P. en 1898. La única referencia de un "herrumbre o roya" en el género *Enterolobium* en la especie *E. cyclocarpum* es de Cuba y comunicada por J. C. Arthur en 1921 (Dr. George B. Cummins, comunicación personal), causada por *R. havanensis* Diet. Este patógeno ha sido también encontrado en Costa Rica y existen ejemplares en el Herbario de la Universidad de Purdue, Indiana (Dr. Cummins comunicación personal). En Costa Rica se han encontrado únicamente dos especies de *Ravenelia*. *R. appendiculata* Lagh. et Diet (13) y *R. ectypa* Art. Holw. (12), la primera en un *Phyllanthus* y la segunda en *Calliandra gracilis*.

Las plántulas de *E. cyclocarpum* fueron colectadas por el segundo autor a fines de abril de 1958, bajo un árbol adulto de esa especie que crecía en un bosque de galería en Ciudad Colón de Mora, San José, a 780 m de altura. Estas tenían aproximadamente un mes de edad, ya que la germinación en esta especie ocurre en forma natural al inicio de las lluvias. Fueron trasladadas en bolsas con tierra húmeda del sitio donde crecían, a un invernadero de la Escuela de Biología, de la Universidad de Costa Rica, en San Pedro de Montes de Oca, donde fueron plantadas en potes metálicos con tierra procedente de un bosque pionero de esta última localidad. Aproximadamente un mes después de crecer en invernadero las plantas mostraron las lesiones típicas del hongo y cinco de ellas se trataron con Fermate. Se colectó hojas y tallos de plántulas afectadas por el hongo, parte de ese material se estudió en cortes hechos a mano y el resto se fijó en FAA, se deshidrató en una serie de alcohol-xilol, se infiltró en parafina y de él se hicieron cortes de 10 mu de espesor que se tiñeron con safranina-verde rápido.

La observación macroscópica evidenció la presencia de uredosoros con grandes cantidades de uredósporas de color pardo. Los cortes manuales de hojas y tallos mostraron ecidios uredinoides acompañados de abundantes espermogonios, ambas estructuras subcuticulares; las uredósporas individuales, son pardas, pediceladas, con poro germinativo y una pared gruesa espinulosa. Las preparaciones teñidas muestran zonas subcuticulares hipertrofiadas con es-

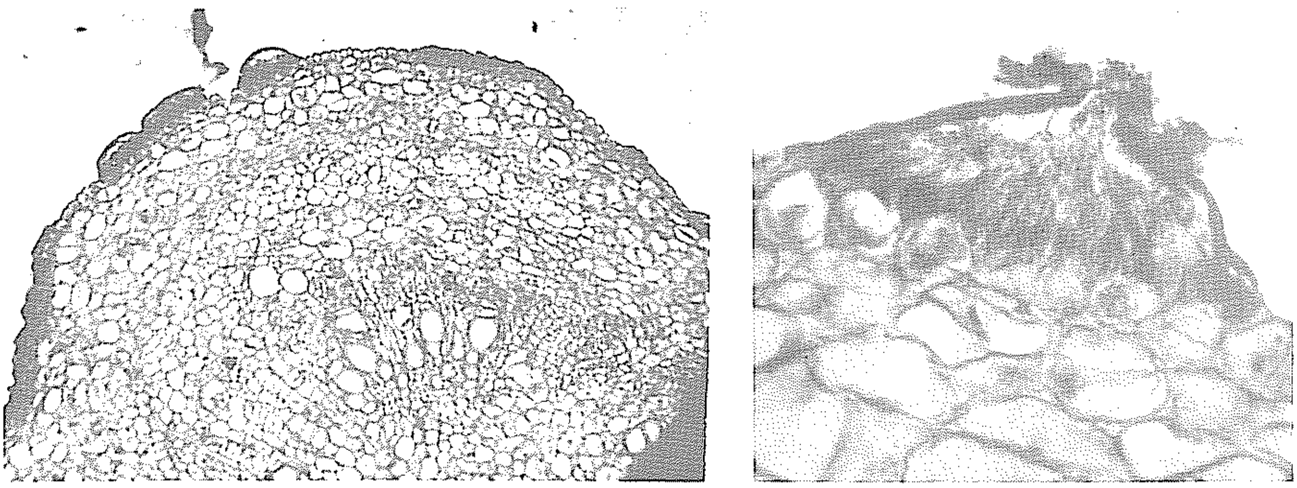

Fig. 1. Cortes transversales de tallos de plántulas de *E. cyclocarpum* mostrando espermogonios subcuticulares de *R. lagerheimiana* a la izquierda x 50. A la derecha espermogonio con espermacios x 400.

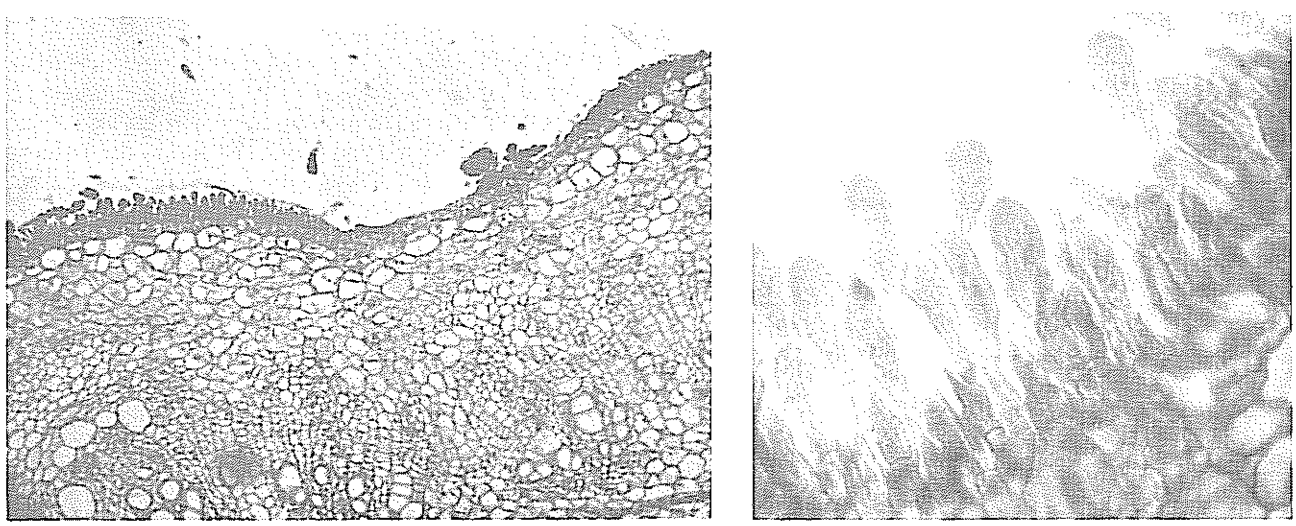

Fig. 2. Cortes transversales de tallos de plántulas de *E. cyclocarpum* mostrando uredosoros subcuticulares a la izquierda x 50 y uredósporas de *R. lagerheimiana* a la derecha x 400

permogonios cónicos, subcuticulares, conteniendo abundantes espermacios (Figura 1), así como uredosoros subcuticulares, casi continuos en la periferia de los tallos principales o sus ramificaciones (Figura 2). No se localizaron teleutósporas. Las plántulas tratadas con fungicida (Fermate) se recuperaron y desarrollaron normalmente. Las no tratadas dieron origen a extensas zonas hipertrofiadas (Figura 3). El tallo principal produjo varios brotes laterales entre dos zonas afectadas: uno de estos brotes se desarrolló como tallo principal, pero al ser de nuevo afectado se repitió el proceso, con lo cual el tallo principal se torna quebradizo y sus hojas se mantienen en estado aparente de marchitez.

Es indudable que la presencia de *R. lagerheimiana* en suelos de nuestro país puede constituir un factor importante en la propagación de nuestro árbol nacional, importante no sólo como símbolo, sino también desde el punto de vista económico, al ser su madera muy utilizada industrialmente. Este hallazgo podría conducir a realizar estudios sobre la distribu-

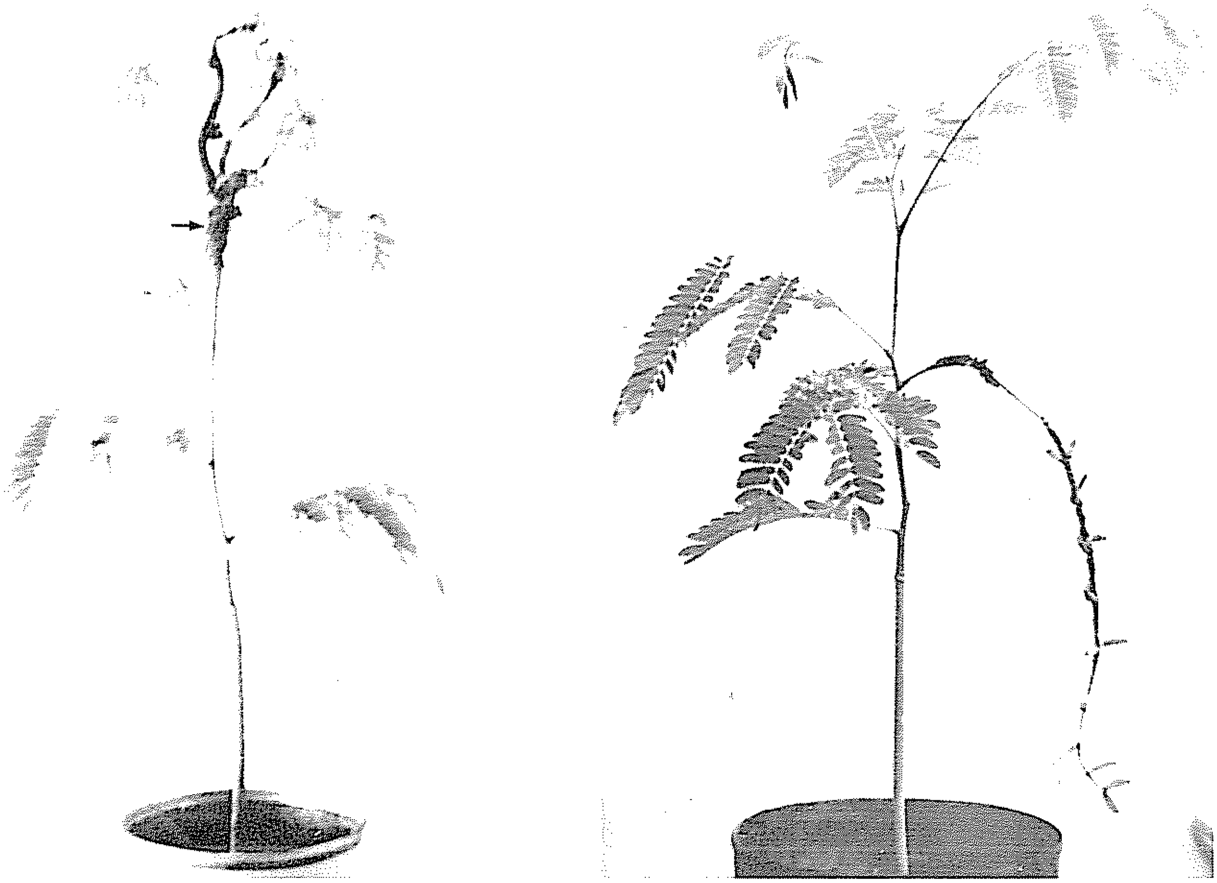

Fig. 3. Plántulas de *E. cyclocarpum* mostrando el efecto del parasitismo de *R. lagerheimiana* en el tallo principal y ramas secundarias 1/3 x.

ción del patógeno en suelos en donde crece especialmente el hospedero.

Resumen

Se comunica por primera vez la presencia de *Ravenelia lagerheimiana* Diet. como parásito de *Enterolobium cyclocarpum* (Jacq.) Gris., colectadas en su medio natural y trasladadas a invernadero de otra localidad, en donde un grupo fue tratado con fungicida (Fermate). Se ilustra y se describe la presencia de ecidios uredinoides (uredosoros) y espermogonios en los tallos jóvenes de las plántulas. Se hacen algunas observaciones de carácter ecológico. Se informa, asimismo, del récord no publicado hasta ahora de *R. havenensis* Art. en el mismo hospedero.

Reconocimiento

A los especialistas Dr. George B. Cummins de la Univ. de Purdue y al Dr. John W. Baxter por la identificación final de la especie patógena.

25 de marzo, 1981.

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The correlation between visual scoring and chemical analysis of starch in *Robusta coffee*.

Resumen. Se establece la correlación entre el contenido de almidón estimado en forma visual y química para café robusta. El coeficiente de correlación (R) varió con la reacción de la planta utilizada, siendo no significativo cuando se empleó tejido cercano al sétimo internudo.

The importance of carbohydrates in vegetative growth, flower bud initiation, development, blossom, fruit set and berry growth in coffee is well known and established (1, 5, 6).

Carbohydrates which are mainly stored in the form of starch as reserve food material in the wood can be estimated quantitatively through chemical analysis. The need for assessment of starch through a simple, reliable and rapid method without involving time consuming processes is generally felt, so that any grower should be able to know the carbohydrate status of a plant by carrying out simple tissue tests in the field. Wormer and Ebagale (7) developed a method which was later modified by Janardhan *et al.* (2) for the assessment of starch in the fresh wood of arabica coffee by visual scoring which showed positive correlation with chemical analysis. The present communication deals with studies on visual scoring and chemical analysis of starch in robusta coffee.

Twenty non-bearing tertiary branches from forty-seven year-old robusta plants (spacing 9' x 9') grown under both temporary and permanent shade trees at Central Coffee Research Institute estate were collected at random from ten plants. The starch assessment was done in the branches depending upon the development of blue colour in the pith region (2). The visual scoring was carried out in all the tertiary branches covering all the seven internodes as described above. In each tertiary branch which was used earlier for visual assessment, internode-wise quantitative chemical estimation of starch was carried out using unicam spectrophotometer by the method of McCready *et al.* (3) as modified by Patel (4) for coffee.

The results of the study indicate that starch index ranged from 8 to 19.75 percent in the non-bearing branches of robusta plants. Maximum starch index of 19.75 percent was recorded in the second internode whereas minimum starch index was recorded in the seventh internode (8%). However, it is interesting to note the pattern of starch index in different portions of the branch. The apical portion had lower starch index as compared to basal portion of the branch. The actual chemical analysis of starch in a branch has shown that it ranged from 2.34 to 3.28%. Maximum starch content (3.28%) was recorded in the sixth internode whereas the fourth internode recorded minimum starch content (2.34%) (Table 1). When values of starch index and starch content were compared in a branch it was generally found that a higher starch index recorded by visual scoring did not give more starch content, when the same material was subjected to chemical analysis. However, in spite of these variations between visual scoring and chemical analysis of starch a correlation was found between two methods of estimation. The data on starch index, starch content and results of statistical analysis are given in Table 1.

Table 1. Correlation between visual scoring and chemical analysis of starch in S.274 robusta branch. (mean of 20 branches).

Internode Number	Starch[1] index	Starch[2] content	Correlation coefficient
1	14.75	2.62	+ 0.7854**
2	19.75	2.52	+ 0.8441**
3	13.75	2.63	+ 0.7705**
4	12.75	2.34	+ 0.7690**
5	15.75	3.16	+ 0.8701**
6	14.50	3.28	+ 0.9501**
7	8.00	2.74	+ 0.4394ns

1 By visual scoring in percentage.

2 By chemical analysis, percentage of dry weight

It is clear from the above data that out of seven internodes in a branch, in six internodes the visual assessment of starch was positively correlated with actual chemical analysis (at 1% probability level).

Acknowledgement

Thanks are due to Shri S. Vishveswara, Director of Research for keen interest shown in the work.

Summary

Correlation was established between visual scoring and chemical analysis in robusta coffee. The correlation coefficient (R) varied with the reaction of the plant used, although it proved to be non significant in the seventh internode.

April 12, 1981.

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El hongo *Erynia neoaphidis* infectando el áfido *Rhodobium porosum* en Venezuela.

Summary. *Erynia neoaphidis* is identified as parasiting the aphid *Rhodobium porosum* Sanderson (Homoptera: Aphididas) found in roses (*Rosa* sp.) in Venezuela. The fungal structure found in dead bodies of aphids corresponded to primary conidias of 15 x 24u x 12 x 15u, $\bar{x}$ = 22 x 12u, and secondary conidias of 13 x 21u x 12 x 15u, $\bar{x}$ = 17x 13u in length- and withd respectively.

Los hongos de la familia Entomophthoraceae se han estudiado debido a su relación parasítica con otros organismos. Entre los que se hallan insectos y arácnidos de importancia agrícola o médica. Por esta razón se ha pensado en varias oportunidades en usar a estos hongos como agentes de control biológico en agricultura o salud pública.

Se conocen estudios sobre este tema en Europa y Norteamérica (1, 2), pero no sucede lo mismo en el estudio de estos hongos en Latinoamérica. Las citas de aislamientos de hongos entomophthoraceos en Latinoamérica son escasas y en muchos casos sumamente vagas no llegándose en general a mencionar más que el género del entomophthoral encontrado infectando un cierto hospedero.

En esta comunicación se informa la ocurrencia de un hongo entomophthoraceo en Venezuela y se presentan algunas de sus características morfológicas. Se espera que esta información permita a otros investigadores la identificación de este hongo en otras localidades de Latinoamérica.

Durante diciembre 1980, se encontraron numerosos áfidos *Rhodobium porosum* Sanderson (Homoptera: Aphididae) muertos sobre el envés de hojas de rosas (*Rosa* sp.) en Maracay, Estado Aragua. Los áfidos estaban momificados, conservando gran integridad estructural y presentaban una costra café clara cubriendo su cuerpo (Figura 1). Los cadáveres estaban pegados a la lámina foliar por su superficie abdominal ventral por micelio (Hifas 4.4 u diámetro; n = 7, s = 70). Al ser examinado los cadáveres usando microscopio compuesto se hallaron las siguientes estructuras de un hongo del grupo de los entomophthorales: a) conidias de tipo oblongo con base 15-24u x 12-15u (promedio 22 x 12u; n = 32, s = 2.50 y 0.60 para largo y ancho, respectivamente) (Figura 2). Estas conidias son lanzadas por los conidió-

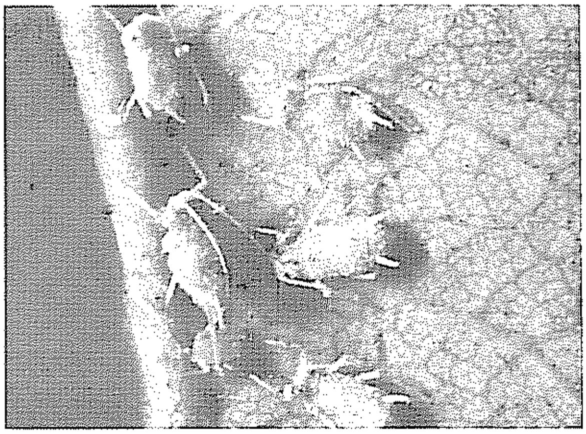


Fig. 1. Momias de *R. porosum* muertos por *E. neoaphidis* sobre hojas de rosa (25 X).

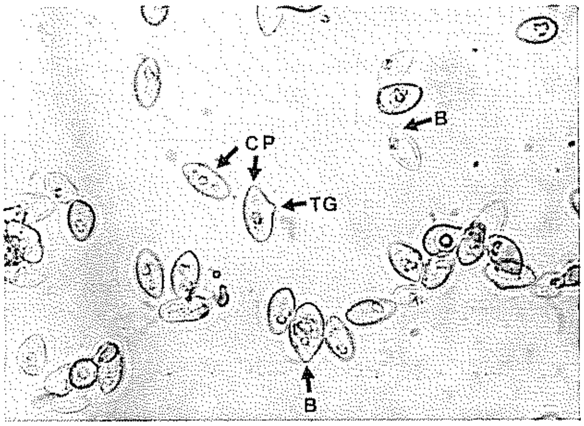
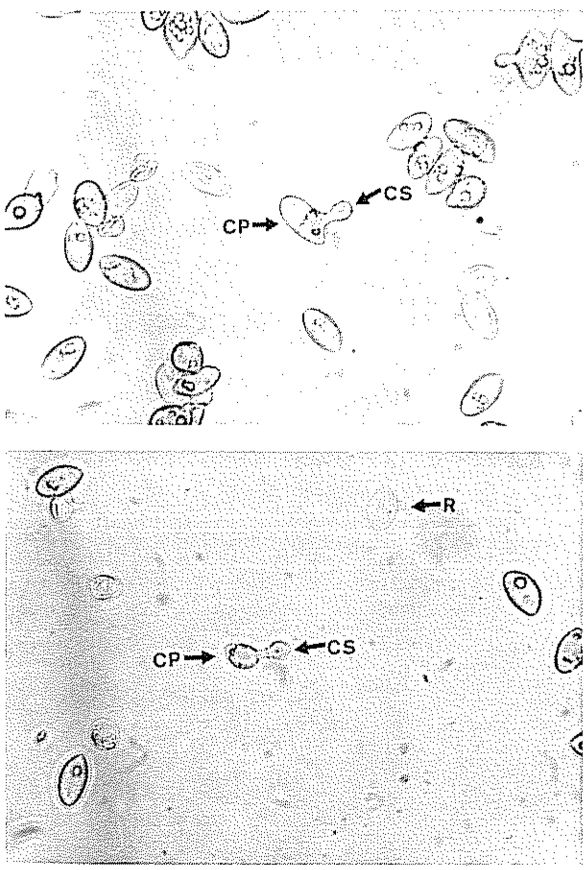


Fig. 2. Conidias primarias de *E. neophidis*. Una de ellas empieza a germinar para producir una conidia secundaria (CP = Conidia primaria; TG = tubo de germinación; B = base de conidia) (425 X).



Figs 3-4 Proceso de formación de conidia secundaria a partir de conidia primaria (CP = conidia primaria; CS = conidia secundaria) (425 X).

foros lejos del cuerpo momificado del áfido al colocarse éste en una atmósfera húmeda. En menos de 24 horas, luego de haber sido lanzadas de sus conidióforas, las conidias primarias empiezan a germinar. El primordio del tubo de germinación se convierte en un conidióforo al extremo del cual se forma una conidia secundaria (Figuras 3 y 4). Las dimensiones de estas conidias secundarias son 13-21u x 12-15u (promedio 17 x 13 u; n = 20, s = 1.80 y 1.6 para la mayor y menor dimensión, respectivamente) Las

Cuadro 1. Comparación de las dimensiones de conidias primarias y secundarias del hongo *Erynia neoaphidis* infectando el áfido *Rhodobium porosum*.

Conidia primaria	Conidia secundaria
15-24 u x 12-15 u X̄ = 22 x 12 u	13-12 u x 12-15 u X̄ = 17 x 13 u

características morfológicas del hongo coinciden con las características del hongo *Erynia neoaphidis* Remaudiere y Hennebert (Entomophthorales: Entomophthoraceae). Este hongo, alrededor del cual ha girado por gran tiempo discrepancias taxonómicas, es un patógeno de áfidos en Asia, Europa, Africa del Norte, Norteamérica, Suramérica y Australia (3).

Se agradece al Dr. G. Remaudiere (Instituto Pasteur, Paris, Francia) sus comentarios en una revisión preliminar de este manuscrito.

Resumen

Se identifica el hongo *Erynia neoaphidis* como parásito del áfido *Rhodobium porosum* alimentándose en rosa (*Rosa* sp.). Las estructuras fungales encontradas en los cadáveres del áfido corresponden con conidias primarias de 15-24 u x 12-15 u, x = 22 x 12u) y conidios secundarios de 13 x 21 u x 12 x 15 u, x = 17 x 13 u en largo y ancho respectivamente.

23 agosto, 1981

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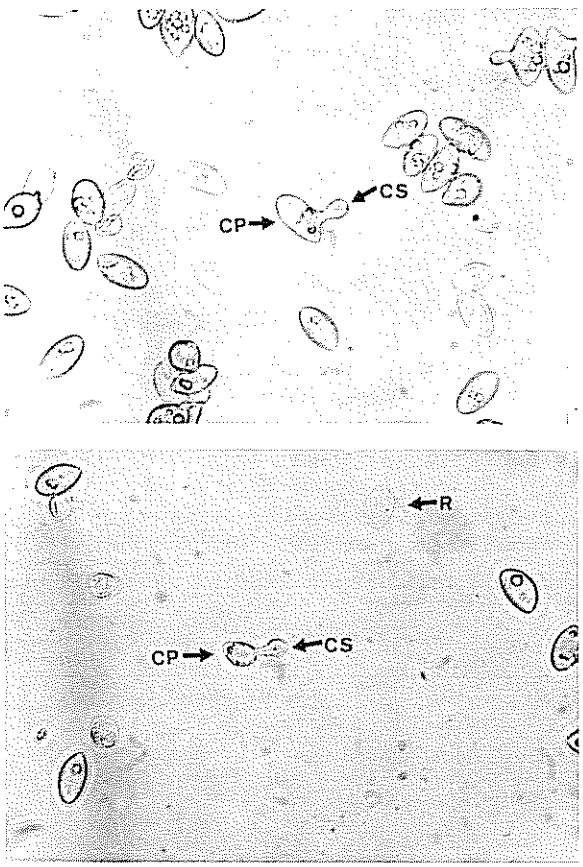

Figs. 3-4 Proceso de formación de conidia secundaria a partir de conidia primaria (CP = conidia primaria; CS = conidia secundaria) (425 X).

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Cuadro 1. Comparación de las dimensiones de conidias primarias y secundarias del hongo *Erynia neoaphidis* infectando el áfido *Rhodobium porosum*

Conidia primaria	Conidia secundaria
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Bound gibberellins in *Prunus avium* L. cv. Mericier seeds.

Resumen. Se determinó la presencia de giberelinas libres y combinadas durante la estratificación en frío, en semillas de guindo dulce cultivar Mericier, sin endocarpo. Se probó el uso de las fosfomonoestearasas aplicadas después de someter los extractos a cromatografía en capa fina.

Ambas formas de giberelinas fueron encontradas en semillas en estado latente y estratificadas; en estas últimas la mayor actividad ocurrió después de 47 días de estratificación. Las giberelinas combinadas aumentaban su actividad en forma paralela a la de las giberelinas libres, sugiriendo que no hubo interconversión de la forma libre con la forma combinada. Por otra parte, semillas estratificadas en presencia del retardador del crecimiento AMO–1618 no mostraron una reducción significativa en su capacidad de germinación.

Mericier sweet cherry is a french cultivar introduced in Chile during the last century. Two types have been developed, black and red. The seed of the two types is characterized by the color of the endocarp. They differ in germination capacity and chilling requirement and both are extensively used as rootstocks (2). Little is known about the role of low temperature in breaking dormancy. One of the effects of stratification is the activation or release of several growth regulators such as gibberellins (3, 5, 6, 7). Proctor and Dennis (5), working on sweet cherry var. Schmidt, detected no changes in gibberellin-like substances in dormant versus non-dormant seeds. They also found no differences in germination capacity and in gibberellin content of the seeds.

The present study was undertaken to assess free and bound gibberellin content of sweet cherry seeds and to determine the possible connection of gibberellin content with the germination capacity of the seeds.

Materials and methods

Samples of seeds of red Mericier were obtained from a commercial orchard in Central Region of Chile, in 1978. The fruits were brought to the laboratory, and the seeds isolated and the endocarp removed. The isolated seeds were surface sterilized in 0.25% hypochlorite for 15 minutes, rinsed in sterile water and stratified in sterile sand or in filter paper (Whatman 3), moistened with distilled water or a solution of 1 mM or 0.1 mM or 0.1 mM of AMO–1618 for 90 days. Two samples of 30 or 50 seeds were removed after 0, 30, 47 and 90 days and analyzed for gibberellins. Also, two or three samples of 50 seeds were removed at each time to test germination capacity. For the gibberellin test, the seeds were immersed in methanol 80%, ground with a mortar and pestle and left overnight at 4°C. The supernatant was centrifuged at 2000 rpm and the residue evaporated under vacuum at 40°C. The residue was dissolved in 15 ml of phosphate buffer, pH 7.3, which was processed to give neutral hexane and ethyl acetate fractions, in conjuction with free and bound forms, according to the slightly modified method of Mielke and Dennis (1975).

Thin layer chromatography

Both free and bound fractions were spotted separately on pre-coated 20 x 20 cm glass plates coated with silicagel 60 F_{254} thickness 0.25 mm (E. Merck, Germany) and co-chromatographed with synthetic GA_3. The plates were developed with ethyl acetate-chloroform acetic acid (15:5:1). After developing the plate to 10 cm the chromatograms were divided into 5 equal zones, scraped and eluted with methanol. The eluates were evaporated to dryness and used for assay.

Bioassay

Phosphodiesterase or phosphomonoesterase activity was used as a bioassay to estimate the gibberellin content. To avoid slight variation in responses from one bioassay to the next, care was taken to test all Rfs of free and bound fractions of one experiment in the same run of an assay. Each Rfs to both free and bound fractions was dissolved in 1 ml of solution containing 250 ug streptomycin sulfate, 0.02 M $CaCl_2$ and embryoless barley seeds, shaken for 16-20 hours on a mechanical shaker in a stoppered test tube. Five milliliters of distilled water were added to each tube, which were throughly shaken and the supernatant centrifuged at 2000 rpm for 5 minutes. One milliliters of the extract was assayed for phosphomonoesterase activity. Typically 0.5 ml of 0.05 M sodium acetate buffer, pH 4.8 and 0.10 ml of bis-p-nitrophenyl phosphate (0.11 mg/ml) were incubated at 37°C for 10 minutes. After addition of 1 ml of NaOH 10% the bis-p-nitrophenyl produced was read at 405 nm in a spectrophotometer (Shimadzu UV 140–02 Kyoto, Japan).

Results and discussion

Seed germination was checked after 10 days of incubation at 20°C in the dark. AMO–1618 only slightly affected the germination capacity of the seeds after 90 days of chilling. However, 1 mM

Abbreviations: AMO–1618 4-hydroxy-5-isopropyl-2-methyphenyl trimethyl ammonium chloride piperedine carboxylate; GA_s gibberellins; GA_3 gibberellin A_3

Table 1. The effect of AMO–1618 on the germination capacity of sweet cherry endocarp-free seeds cultivar red Mericier, after 90 days of treatment at 5°C. Values are means of 3 samples of 50 seeds each.

Treatment	Germination (%)[1]
AMO– 1618	
10^{-4} M	80a
10^{-3} M	55b
Distilled water	64b
GA_3 10^{-4} M	100ac

1 Means followed by the same letter are not significantly different at 5% level as determined by Duncan's multiple range test.

AMO–1618 slightly reduced germination from 64% to 54%. On the other hand, 0.1 mM AMO–1618 stimulated it (80% versus 65%) and GA_3 0.1 mM gave 100% (Table 1).

The distribution of gibberellin-like activity prepared from acidic ethyl acetate extract of whole sweet cherry seed on thin layer chromatography is shown in Figure 1. Both forms of GA_3 reached the highest level at 47 days of stratification and decreased to the level of dormant seeds after 90 days. Bound and free fractions paralleled their activity throughout the chilling period. Germination reached 94% by the end of the cold treatment.

The free gibberellin content of the whole seed, expressed in terms of gibberellin A_3 equivalent

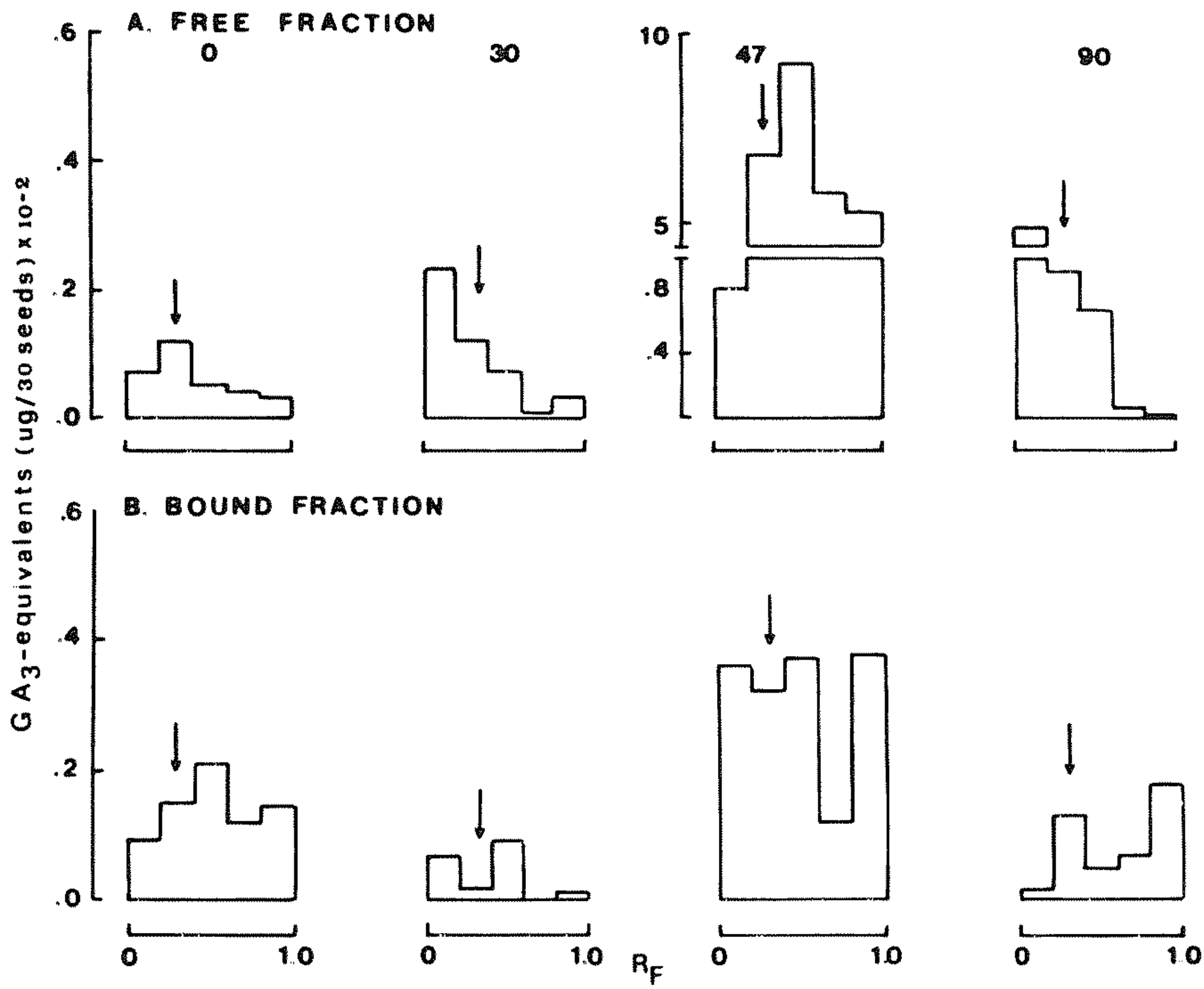

Fig. 1. Gibberellin-like activity in red Mericier sweet cherry at 0, 30, 47 and 90 days of stratification at 5°C. Detection was performed by measuring the activity of phosphodiesterase secreted by embryoless barley seeds after thin layer chromatography. A free form and B bound form. Arrows represented the Rfs of GA_3. Germination rates were 4% and 94% after 47 and 90 days respectively. Number on the top of each histogram represent time of stratification.

per 30 seeds at 0, 30, 47 and 90 days of chilling were 0.125 x 10^{-2}, 7.25 x 10^{-2} and 0.230 x 10^{-2} ug respectively. Thus, there was an approximately 60-fold increase of free gibberellin-like activity after 47 days, while a twofold increase in the bound form was observed in the material which showed very low (4%) germination.

The content of gibberellin-like substances in sweet cherry seeds undergoes changes during stratification, reaching a peak of activity after 47 days at 5°C for both free and bound forms. When seed germination capacity was very low (4%) the free form was predominant. This agrees with results reported for apple sees (6). However, AMO–1618 slightly reduced the germination ability of the seeds as has been observed for Golden Delicious apple seeds (1). The most characteristic and predominant of both fractions varied between Rf 0.2 – 1.0 reaching the highest level following 47 days of stratification. These results indicate no transformation of inactive bound gibberellin into free active form(s) during the chilling treatment. The same result has been reported for apple seeds (1).

The lack of effect of AMO–1618 in these seeds might be explained either assuming that the seeds have metabolized this substance or that the seeds are not sensitive to AMO–1618. This study did not confirm results reported by Proctor and Dennis (5). They reported no changes of GA_5 during stratification of sweet cherry seed var. Schmidt. This discrepancy may be due to either the use of a different variety or that the technique used to detect GA_5 activity which was not sensitive enough.

Experiments on the seed of *Prunus avium* Mericier indicated that gibberellin A_3 promotes the germination of sweet cherry when it was included in the stratification medium. However, as the dry storage period is prolonged not only gibberellins but also chilling fails to break the dormancy (unpublished results) of these seeds. Thus a stage is reached where the dormant seeds are unable to respond to both chilling and plant hormones.

Summary

Total free and bound forms of gibberellins were determined during stratification in endocarp-free seeds of sweet cherry cultivar Mericier using the phosphomonoesterase test applied after thin-layer chromatography.

Both forms of gibberellins were detected in dormant and after-ripened seeds and the highest levels of activity occurred after 47 days of stratification. Bound gibberellins parallel the activity of the free ones, suggesting no interconversion of the bound form into the free one. Seeds stratified in presence of the growth retardant AMO–1618 did not show significant reduction in the germination ability of the seeds.

Acknowledgements

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Faunistique et bioecologie des noctuelles (*Lepidoptera, Noctuidae*) des Antilles Françaises.

Summary. Noctuid moths constitute a serious pest problem in the French Antilles. Of the 127 species present, twenty are of agricultural concern. Noctuid moths are limiting corn production. The article discusses population dynamics, parasites and insect-plant relationships. A local corn ecotype seems more resistant than the imported variety, bred in Europe.

Les problèmes agronomiques posés par les Noctuelles aux Antilles Françaises s'avèrent extrêmement graves sur les cultures fourragères et vivrières. Ces insectes sont parfois de véritables facteurs limitant de l'introduction ou du développment de certaines cultures alternatives tel le mais. Cette plante, qui est extrêmement répandue en culture associée dans certaines îles de l'Archipel Antillais, peut s'avérer très intéressante dans le cadre de la diversification de l'agriculture de la Guadaloupe en particulier en association avec la canne à sucre.

Les données disponibles restent sur ce très vaste problème phytosantaire très fragmentaires et traitent d'observations éparses de pullulations des espèces les plus nuisibles à l'agriculture antillaise (1).

Nous présenterons plus particulièrement la faunistique de ces insectes, l'inventaire de leur biocénose parasitaire ainsi que la dynamique des populations des chenilles de deux espèces très nuisibles au mais: *Spodoptera frugiperda* A. et S. et *Heliothis zea* BODDIE.

Faunistique des Noctuelles des Antilles Françaises

Une liste, la plus complète, a été établie à partir des captures. Il a été tenu compte également des noctuelles de plusieurs collections de référence préexistantes. Ces observations intéressent toute la région Guadeloupe avec ses dépendances (Marie-Galante, la Désirade, les Saintes, St Martin et St Barthélémy) et la Martinique (Figura 1).

Les échantillonnages ont été effectués au piège lumineux ou par prélèvement des chenilles dans la nature pour élevage jusqu'à l'imago.

Au total, 127 espèces ont été recensées. Une partie est encore en cours d'identification ou de description pour les espèces nouvelles. Ces dernières seraient au nombre de trois (TODD, communication personnelle) dont une appartenant au genre *Eriotyga*

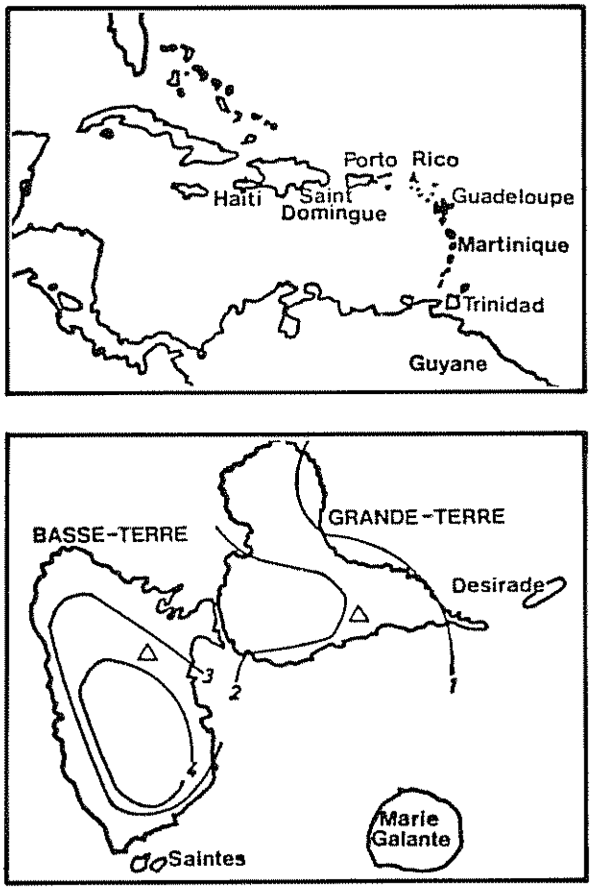

Fig. 1. Position de la Guadeloupe et de ses dépendances dans l'Archipel Antillais et zones ou ont été effectuées les plantations de maïs en Guadeloupe (Δ). Pluviométrie: 1 = inf. à 1 m; 2 = 1.50 m; 3 = 2.50 m; 4 = 3.50 m.

Une autre espèce, *Strictoptera vitrea* GUENEE est rencontrée pour la première fois dans les petites Antilles. Dix sous-familles sont représentées dans cet inventaire et certaines sont connues pour leur impact économique. *Hadeninae, Agrotinae, Anphypyrinae, Heliothinae, Acontiinae, Euteliinae, Plusiinae, Catocalinae, Erebiinae, Hyperinae*

Parmi toutes les espèces recensées une vingtaine (Tableau I) sont d'importants ravageurs des systèmes de production agricoles des Antilles.

Inventaire de la Biocenose Parasitaire

Avant d'envisager une intervention brutale pour limiter les dégâts de ces phytophages, il était nécessaire d'étudier la biocénose parasitaire et l'efficacité des principaux entomophages impliqués.

Les principaux parasites et prédateurs on été isolés par prélèvements d'oeufs et de stades préimaginaux des noctuelles dans la nature. Les intervenants les plus communs et les plus efficaces sont:

a) les diptères Tachinaires, parasites des larves et nymphes.

b) les Hyménoptères, *Trichogrammatidae* et *Scelionidae*, parasites des oeufs embryonnés.

Le parasitisme s'est avéré plus élevé en Basse-Terre qu'en Grande-Terre (Figure I).

Quelques prédateurs sont également présents: un Calosome (*Calooma alternans*, Coléoptère *Carabidae*) (2), une guêpe très commune (*Polystes tricolor*, Hyménoptère *Vespidae*) et de nombreuses punaises (Hétéroptères). Quelques vertébrés jouent un rôle d'auxiliaires non négligeable lors des pullulations: les crapauds (*Bufo marinus*), les lézards (*Anolis marmoratus*) et divers oiseaux carnivores ou omnivores.

La biocénose parasitaire et prédatrice parait donc bien représentée avec une réelle efficacité courante. En dépit de ceci, la soudaineté des pullulations de ravageurs est telle qu'un laps de temps plus ou moins long reste nécessaire afin que les entomophages arrivent à des niveaux de populations suffisants pour contrôler le phytophage. C'est au cours de ce déphasage que les principaux dommages sont occasionnés aux cultures.

Dans ces conditions, il ne semble pas envisageable d'adopter pour stratégie une acclimatation d'entomophages allochtones en Guadeloupe mais plutôt de chercher à renforcer l'action des principaux auxiliaires autochtones par la méthode des lâchers inondatifs.

Tableau 1. Liste des principales espèces nuisibles capturées en Guadeloupe avec leurs plantes-hotes.

Espèces nuisibles		Plantes-Hotes
Alabama argillacea	*(HUBNER)*	Coton
Anicla infecta	(OCHS.)	Maraîchage (vers gris)
Anticarsia gemmatilis	(HUBNER)	Légumineuses
Argyrogramma verruca	(F.)	Maraîchages
Feltia subterranea	(F.)	Maraîchages (vers gris)
Gonodonta spp.	(4 espèces)	Adultes piqueurs de fruits
Heliothis virescens	(F.)	Légumineuses et coton
Heliothis zea	(BODDIE)	Mais surtout
Leucania inconspicua	(H. S.)	
Leucania juncicola	(GU.)	Canne à sucre ; graminées
Leucania latiuscula	(H. S.)	
Mocis latipes	(GU.)	
Pseudoplusia includens	(WALKER)	Maraîchages
Spodoptera androgea	(CRAMER)	
Spodoptera dolichos	(F.)	
Spodoptera eridania	(CRAMER)	Très polyphages ; maraîchages ; fourrages
Spodoptera exigua	(HUBNER)	
Spodoptera frugiperda	(A. S.)	
Spodoptera latisfascia	(WALKER)	Très polyphage ; fourrages verts
Spodoptera sunia	(GU.)	Très polyphage ; maraîchages ; fourrages

Dynamique des Populations des Chenilles de *S. frugiperda* et *H. zea* Sur les mais: Influence de la Variete.

Il est primordial, pour toute méthode de contrôle, de connaître l'évolution dans le temps des populations de chenilles de ces deux noctuelles et de mettre en évidence le stade phénologique le plus sensible du végétal. La sensibilité variétale du mais doit aussi être envisagée. Parallèlement à ces études, les fluctuations du taux de parasitisme sur les larves ont été évaluées.

Les essais ont été effectués en Basse-Terre d'Avril à Mai de l'année suivante sur des parcelles de 100 m^2 plantées avec deux variétés de mais: un antillais "FONDOR" et une variété améliorée européenne "INRA 400". Les échantillonnages ont porté sur quatre stades phénologiques du végétal choisis en fonction de l'écoéthologie présumée du ravageur: stades "6-8 feuilles" "floraison", "émission des soies" et "grains laiteux".

Spodoptera frugiperda la période de pullulation la plus importante se situe de Mai à Juin dans les conditions d'observation de la Basse-Terre. Le stade "6-8 feuilles" est le plus touché par les attaques de ce ravageur et les dégâts sont exceptionnels à partir de la floraison du mais. Sur l'ensemble de l'expérimentation, 19% des plants ont été attaqués au stade "6-8 feuilles" sur la variété européenne contre 4% sur la variété antillaise. Ceci met en évidence une "résistance" variétale indéniable de l'écotype local. Le taux de parasitisme larvaire le plus important a été observé pendant la pullulation de Mai-Juin, mais généralement très faible: 18% à la fin du mois de Juin sur l'ensemble des deux variétés de mais. Le parasitisme était le fait de deux mouches Tachinaires: *Lespesia archippivora* RILEY et *Archytas marmoratus* TOWNSEND.

Heliothis zea: Les pullulations les plus importantes ont lieu à deux périodes: Octobre-Novembre et Février-Mars. Le niveau général des populations reste cependant plus important toute l'année par rapport à *S. frugiperda* avec une dépression marquée de Décembre à Janvier. C'est à partir du stade "grain laiteux" de l'épi que les populations deviennent abondantes. En fait, la pénétration des jeunes chenilles se fait dès la formation de cet organe et les dégâts apparaissent au stade précité. La différence de sensibilité entre les deux variétés se fait déjà ressentir au stade "émission des soies" de l'épi avec 16% attaqués pour "INRA 400" contre 9% pour "FONDOR".

Globalement, les degâts sont bien plus importants sur la variété européenne (74%) que sur la variété antillaise (41%). Une des causes de la résistance de l'écotype "FONDOR" est liée à la morphologie de la gaine de l'épi qui est plus épaisse, résistante et enveloppante. L'épi de la variété présente un sommet pratiquement nu. Il ne faut cependant pas écarter la possibilité d'une résistance d'ordre allélo-chimique. Le taux de parasitisme pratiquement nul n'était dû qu'à la présence d'une mouche tachinaire *Métagonistylum minense* TNS, au moment des plus faibles populations de chenilles

Conclusions

Cette étude, qui se prolongera sur plusieurs années, s'avère nécessaire pour élaborer une stratégie de lutte intégrée capable de limiter les dégâts occasionnés par les noctuidae dans les Antilles françaises.

Les méthodes de lutte devront tenir compte du caractère brusque et imprévu des pullulations catastrophiques dont on ne connaît pas encore les paramètres. Plusieurs hypothèses peuvent toutefois être émises pour en expliquer ces mécanismes:

– l'existence de migrations de papillons adultes, dans l'archipel caraibe (Figure I), ces derniers pouvant franchir des centaines de kilomètres en conditions météorologiques favorables.

– l'intervention de diapauses induites par des périodes climatiques défavorables (sécheresse).

La grande capacité de déplacement de ces insectes et leur polyphagie ne rendent pas simple le maintien d'équilibres stables pour en limiter les populations dans les principales cultures antillaises. Une stratégie orientée vers des méthodes de lutte curatives intégrant des lâchers inondatifs d'entomophages, l'emploi de virus, d'insecticides specifiques et non rémanents, et aidé d'un système d'avertissement agricole efficace (phéromones), paraît être la plus appropriée. A court et moyen terme, il est important d'élargir les investigations vers des méthodes préventives telle une sélection variétale du végétal pour chaque espèce de noctuelles.

Resumé

Parmi les quelques 127 espèces de noctuelles des Antilles Françaises, une vingtaine s'avèrent importantes au plan agronomique. La dynamique des populations, les parasites et les relations chenilles-mais sont étudiés. Un écotype local parait moins sensible que la variété améliorée européenne.

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