DIFFERENCES IN POPULATION INCREASE, HOST PREFERENCES AND FREQUENCY OF MORPHOLOGICAL VARIANTS AMONG ISOLATES OF THE BANANA RACE OF *RADOPHOLUS SIMILIS.*

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Accepted:
20. III. 1981
Aceptado:

ABSTRACT

Tarté, R., J. Pinochet, C. Gabrielli, and O. Ventura. 1981. Differences in population increase, host preferences and frequency of morphological variants among isolates of the banana race of *Radopholus similis.* Nematropica 11: 43-52.

Physiological differences and morphological variations of the banana race of *Radopholus similis* (Cobb) Thorne were studied. Population increase of 6 isolates from different banana growing areas was measured in carrot disk cultures at two intervals. The Honduran isolate presented the lowest reproduction rate at 45 and 75 days, while the Panama-Armuelles and the Ecuadorian isolates showed the highest for the same periods respectively. Four isolates of *R. similis* were inoculated into nine different crops under greenhouse conditions. The Honduran isolate presented the highest population increase in sorghum, cowpea and pigeon pea seven weeks after inoculation as compared to the Panamanian and Ecuadorian isolates. Okra, corn and tick trefoil *(Desmodium ovalifolium)* were poor hosts of the nematode whereas tomato, sweet potato and sour orange were nonhosts. Observations on the morphology of female tails of *R. similis* revealed differences in the frequency of pointed and rounded tails within 13 populations. The ratio of pointed-tailed: rounded-tailed females ranged from 25: 75 to 98.8: 1.2. The Honduran, Guatemalan and Mexican populations showed the highest frequency of pointed-tails. Two pathotypes of the banana race of *R. similis* are recognized in banana producing areas of Central and South America. Their economical importance and possible relationship with morphological features are discussed.

Additional key words: burrowing nematode, pest management, crop rotations, pathogenicity, host range.

RESUMEN

Tarté, R., J. Pinochet, C. Gabrielli, y O. Ventura. 1981. Diferencias en incremento poblacional, preferencias en hospederos y frecuencia de variantes morfológicas entre poblaciones de la raza del banano de *Radopholus similis*. Nematropica 11: 43-52.

Se estudiaron diferencias fisiológicas y variaciones morfológicas en la raza del banano de *Radopholus similis* (Cobb) Thorne. En cultivos de discos de zanahoria se midió el incremento poblacional de 6 poblaciones procedentes de diferentes áreas productoras de banano a dos intervalos de tiempo. La población de Honduras presentó el menor incremento poblacional a los 45 y 75 días, mientras que las poblaciones de Armuelles, Panamá y Machala, Ecuador presentaron respectivamente el mayor incremento poblacional durante los mismos períodos de tiempo. Cuatro poblaciones de *R. similis* se inocularon en nueve diferentes cultivos bajo condiciones de invernadero. La población de Honduras presentó el mayor incremento poblacional en sorgo, frijol arbustivo y gandul siete semanas después de la inoculación, en comparación con las poblaciones panameñas y ecuatoriana. La okra, el maíz y el pega-pega (*Desmodium ovalifolium*) fueron hospederos pobres del nematodo mientras que el tomate, el camote y la naranja agria no resultaron hospederos. Observaciones morfológicas de las colas de hembras de *R. similis* revelaron diferencias en la frecuencia de colas agudas y redondeadas en 13 poblaciones del nematodo. La relación cola aguda: cola redondeada fluctuó de 25:75 a 98.8: 1.2. Las poblaciones de Honduras, Guatemala y México mostraron la frecuencia más alta de colas agudas. Se reconocen dos tipos patogénicos de la raza del banano de *R. similis* en las áreas productoras de Centro y Sur América. Se discute su importancia económica y su posible relación con ciertas caracteristicas morfológicas.

Palabras claves adicionales: manejo de plagas, rotación de cultivos, patogenicidad, gama de hospederos.

INTRODUCTION

The existance of different biotypes of the banana race of *Radopholus similis* (Cobb) Thorne in the banana producing areas of Central America has been suggested by some authors (1, 4). Edwards & Wehunt (1) have reported differences in host preferences between populations of the nematode from Honduras and Panama. Pinochet (4) found that populations from Armuelles and Changuinola, Panama and Coto, Costa Rica, caused greater damage to banana roots than a population from La Lima, Honduras and that the population increase of the Honduras isolate was considerably lower than in the remaining populations. These findings could account for the lower incidence of uprooted plants observed in the Ulua Valley in Honduras as compared to Coto, Costa Rica and Armuelles and Changuinola, Panama.

The possibility of identifying these variants morphologically has been investigated recently. Tarté (5) studied morphological variability in regards to the shape of tail terminus and stylet knobs of females of four *R. similis* populations from Central America reared in monoxenic cultures. Although all populations showed the same morphological variants, the relative frequency of these variants differed within each population. The frequency of females with pointed tail terminus and with indented stylet knobs was greater in the Honduran isolate than in those from Costa Rica and Panama.

The information presented in this paper considers an aspect in banana nematology that has not been given much attention before. The finding of pathogenic variants of the banana race of *R. similis* and their possible relationship with morphology opens an important line of research that would lead to a better understanding of the relationship between the crop and the nematode and consequently, to the development and utilization of better nematode control measures.

MATERIALS AND METHODS

In a recent experiment, population increase of *R. similis* under controlled conditions was measured. Six isolates of the nematode were originally isolated from Valery bananas from the following banana producing areas in Central and South America: 1) La Lima, Honduras; 2) Coto, Costa Rica; 3) Armuelles, Panama; 4) Changuinola, Panama; 5) Machala, Ecuador and 6) Turbo, Colombia. (Fig. 1). All of these areas grow more than 6,000 Ha. of bananas for the export market, except for Coto, Costa Rica, which grows approximately 3,800 Ha. The nematodes from the first five populations were raised in the absence of microorganisms on carrot disks for several generations by the method described by Moody *et al* (3). Amount of substrate per culture jar was calculated based on aliquotes. Male, female and larval population were counted separately. Three counts were made per sample.

In a second experiment, nematodes raised on carrot cultures from the following isolates: 1) La Lima, Honduras; 2) Armuelles, Panama; 3) Changuinola, Panama; and 4) Machala, Ecuador, were inoculated into sorghum "Dorado M" *(Sorghum vulgare),* cowpea "Romefa" *(Vigna sinensis),* pigeon pea "64-2-B" *(Cajanus cajan),* okra "Clemson's Spineless" *(Hibiscus esculentum),* corn "Tocumen 7428" *(Zea mays),* tick trefoil *(Desmodium ovalifolium),* tomato "Rutgers" *(Lycopersicum esculentum),* sweet potato "All Gold" *(Ipomoea batatas)* and sour orange *(Citrus aurantium).* Each crop was grown in 20 cm. pots under greenhouse conditions and inoculated with 500 nematodes of a single isolate. The four isolates were inoculated to all crops.

Each isolate inoculated into a crop was considered a treatment. Each treatment was replicated four times. Nematode densities in the roots were

Fig. 1 Six banana producing areas of Central and South America from where *R. similis* populations were originally isolated.

measured after seven weeks. Nematodes were extracted by blending 10 gm. of roots for 15 seconds, pouring the suspension after passing it through a 325 mesh sieve over a filter on top of a Baermann funnel and collected after 48 hrs. All of the roots were used for nematode extraction in samples in which the weight of the root system was less than 10 gr. Total number of nematodes were calculated based on aliquotes.

A morphological study was conducted on *R. similis* females from seven field populations and six isolates raised monoxenically on carrot disks. Thirty seven to 203 females were observed microscopically from each isolate. The shape of the female tail terminus was characterized and the frequency of each morphological variant was recorded.

RESULTS

Population increase of six R. similis isolates raised on carrot disks.

Table 1 Growth rate and sex ratio of 5 banana populations of *R. similis* from Central and South America at 45 and 75 days after incubation in culture jars

Populations[w]	Increase at 45 Days[x]	Sex Ratio 45 D[y] F[y] M L	Increase at 75 Days	Sex Ratio 75 D F M L
Machala, ECUADOR	11.270 A[z]	9.0 : 1 : 5.4	398.920 A	7.8 : 1 : 4.0
Coto, COSTA RICA	11.500 A	4.7 : 1 : 1.9	318.800 A	4.0 : 1 : 4.4
Changuinola, PANAMA	12.020 A	4.6 : 1 : 2.4	311.320 A	4.6 : 1 : 5.5
PTO. Armuelles, PANAMA	14.350 A	6.9 : 1 : 3.8	160.760 A B	5.4 : 1 : 2.9
La Lima, HONDURAS	1.140 B	4.7 : 1 : 2.7	45.970 B	7.7 : 1 : 4.0

[w] Mean of 5 replicates.
[x] Initial inoculation level was 10 females per culture jar.
[y] F = Female; M = Male; L = Larvae.
[z] Duncan's multiple range test (P = .05).

The Honduran isolate reproduced at a significantly lower rate than the rest at 45 days after inoculation on carrot disks. (Table 1). At 75 days the Honduran isolate also differed from the Panama-Changuinola, Costa Rican and Ecuadorian isolates but not from the Panama-Armuelles isolate. At both 45 and 75 days after inoculation, the Honduran isolate reached the lowest population increase. There were no differences in population increase between the Costa Rican, Panamanian and Ecuadorian cultures for the two periods. The female-male ratio was highest in the Machala-Ecuador population at 45 and 75 days (9:1 and 7.6:1 respectively). The Panama-Armuelles isolate which reached the highest population growth, increased by 12.6 times more than the Honduran isolate at 45 days. At 75 days, the Machala-Ecuador isolate, which reached the highest population growth for that period, increased by 8.6 times more than the Honduran isolate. Several attempts to culture a *R. similis* population from Turbo, Colombia have been unsuccessful in this study and in the past.

Population increase and host preferences of four R. similis isolates raised on different crop and plant species.

The plant species, tomato "Rutgers", sweet potato "All Gold" and sour orange were not attacked by any of the populations. The highest build-up of the nematode occurred in all populations with sorghum "Dorado M" and cowpea "Romefa". However, the number of nematodes recovered per root system in sorghum was approximately 6, 8 and 20 times higher in the Honduran than in the Panama-Changuinola, Ecuadorian and Panama-Armuelles populations respectively and that recovered from cowpea was approximately 2, 4, and 6 times higher in the Honduran than in the Panama-Changuinola, Ecuadorian and Panama-Armuelles populations respectively (Fig. 2). Although the Machala population practically did not reproduce on pigeon pea "64-2-B", this crop followed sorghum and cowpea in host efficiency, and again more nematodes were recovered from the Honduran than from the remaining populations. Okra "Clemson's Spineless", corn "Tocumen 7428" and tick trefoil were poor hosts of the nematode. The only appreciable count occurred in okra for the Honduran population and in corn for the Ecuadorian population.

Frequency of morphological variants of the female tail terminus in 13 R. similis populations.

Observations on the morphology of females of the banana race of *R. similis* revealed the existance of distinct morphological variants of the female tail. Several tail types ranging from finely pointed to flattened were identified. Although the variability might be of a quantitative type, for practical purposes these variants were separated into two groups: pointed tails and rounded tails (Fig. 3). The frequency of such variants differed among different populations of the nematode. In 13 populations studied from Mexico to

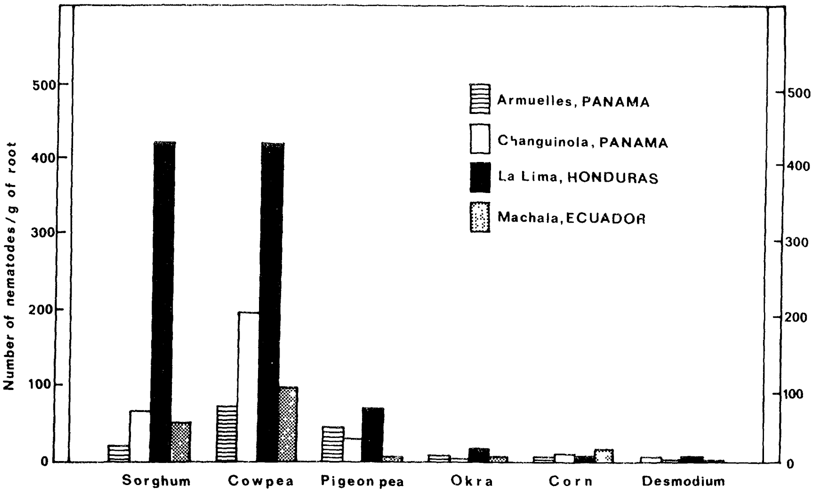

Fig. 2 Differences in reproduction and host preferences of four populations of *R. similis* from Central and South America.

Ecuador the ratio of pointed-tailed: rounded-tailed females ranged from 25:75 to 98.8: 1.2 (Table 2). Of those populations used in our studies of population increase and host preferences that from La Lima, Honduras showed a higher frequency of pointed-tailed females (48.2%) as compared to those from Machala, Ecuador (25.6%), Changuinola, Panama (28.8%), Armuelles, Panama (25%) and Coto, Costa Rica (36.8%).

DISCUSSION

The studies on population increase and host preferences confirm the existance of physiological variation among the banana race of *R. similis*. Although some differences in host preferences were revealed, the main differences appear to be related to rate of reproduction. In this respect the Honduras isolate significantly differed from the others, having a lower population increase in carrot disks and a higher population increase when inoculated to cowpea, sorghum and pigeon pea. Although the rate of population increase differed according to the host, the lower rate obtained with the Honduras isolate on carrot disks coincides with that obtained on Valery banana in a previous experiment (4). This physiological difference might explain why losses due to *R. similis* in the banana producing area of the Ulua Valley in Honduras are not important as compared to the losses that occur in Costa

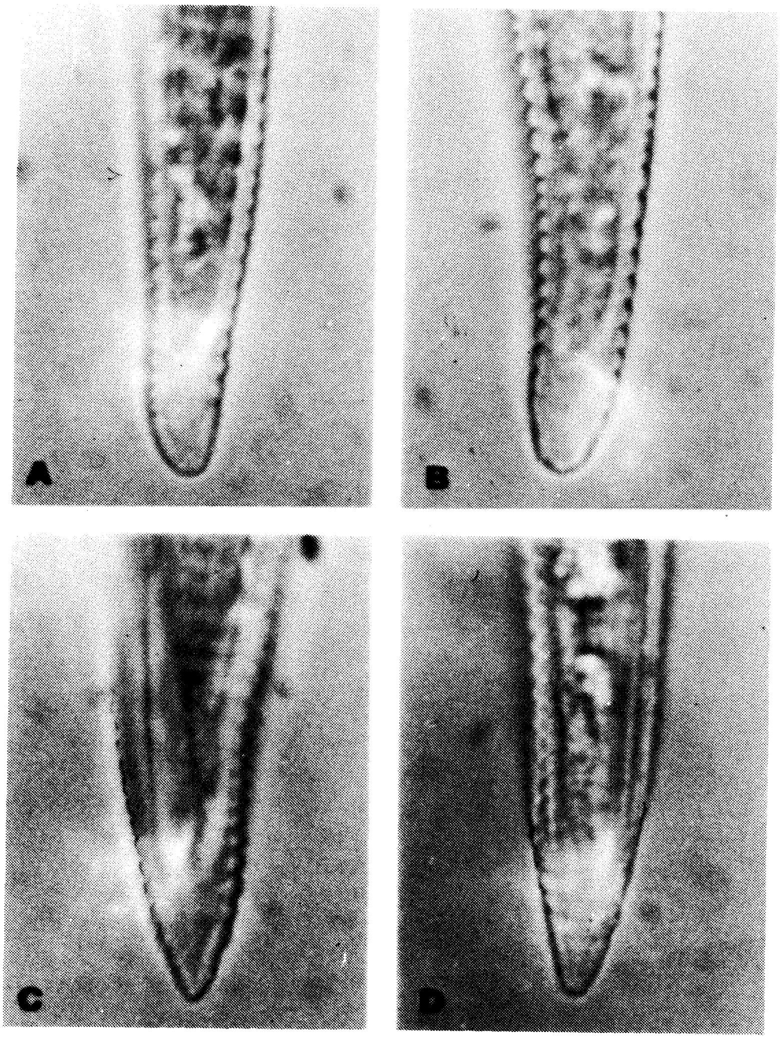

Fig. 3 Morphological variants in *R. similis* females. A, B, rounded tail terminus; C, D, pointed tail terminus.

Rica, Panama and Ecuador where nematicides are commonly used and there is a response to them. More pathogenic forms seem to predominate in these countries.

The failure to culture an isolate from Turbo, Colombia, in this study and in the past seems to be related to the conditions and procedures in which field

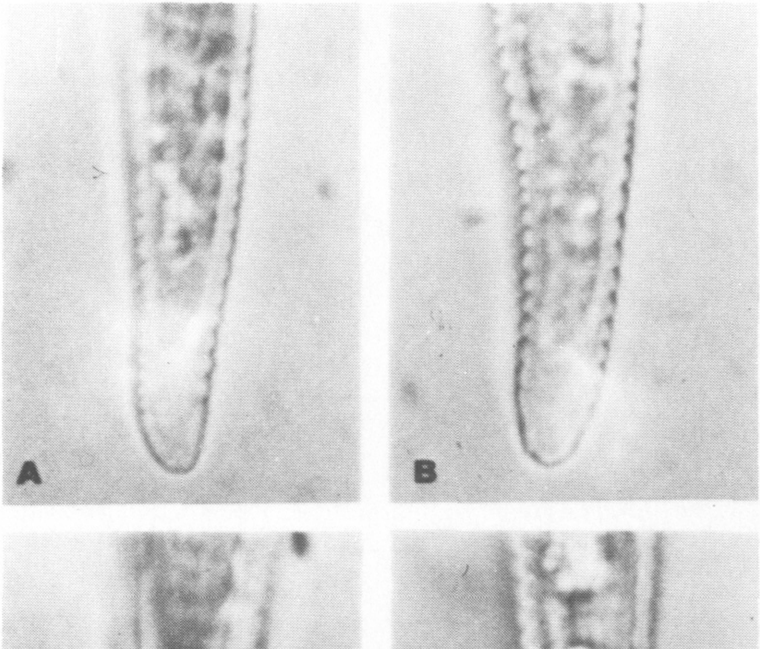

Fig. 3 Morphological variants in *R. similis* females. A, B, rounded tail terminus; C, D, pointed tail terminus.

Table 2 Differences in the frequency of female tail variants in several populations of *Radopholus similis* from banana growing areas of Central and South America

Population	No. of Females Observed	Frequency (%)	
		Pointed Tail Terminus	Rounded Tail Terminus
ECUADOR, Machala (1)	203	25.6	74.4
PANAMA, Changuinola (1)	201	28.8	71.1
PANAMA, Armuelles (1)	200	25.0	75.0
COSTA RICA, Coto (1)	201	36.8	63.2
COSTA RICA, Siquirres (2)	37	40.5	59.5
COSTA RICA, Guápiles (2)	40	27.5	72.5
HONDURAS, San Juán*(2)	196	44.9	55.1
HONDURAS, La Lima (1)	197	48.2	51.8
HONDURAS, Los Indios*(2)	200	53.5	46.5
HONDURAS, Higuerito*(2)	201	63.7	36.3
HONDURAS, Los Limones*(2)	172	98.8	1.2
GUATEMALA, Bandegua (2)	46	69.5	30.5
MEXICO, Tapachula (1)	202	63.4	36.6

* Banana farms of the Ulua Valley in Honduras
(1) From population reared in carrot disc culture
(2) From field population

samples were handled for 2-3 days prior to nematode extraction in Honduras. It is likely that the nematode loses the ability to penetrate and colonize host tissue. The nematode's mobility also seems to be affected.

For practical purposes it would be interesting to know the distribution of these two recognized degrees of pathogenicity among isolates of *R. similis* in banana producing areas of Central and South America, since it would help improve production through nematode control practices in banana plantations where *R. similis* is a problem. It would also reduce the use of nematicides in areas where they are not needed.

It would be very helpful if these pathogenic variants could be identified morphologically. The higher number of pointed-tailed females observed in the Honduran isolate suggests the possibility that they could be less pathogenic to bananas than rounded-tailed females of the nematode. Observations made by the authors in many banana growing areas of Central and South America have indicated a higher frequency of pointed-tailed females in areas where losses due to nematodes are not important as compared to areas where nematode damage is severe.

A relationship between pathogenicity and morphological characteristics of the female tail has been established for *Pratylenchus penetrans* (6) and we believe a similar situation may occur with *R. similis*. We recognize the existance of at least two pathogenic variants and have shown some evidence for the posibility that these variants are related to the indicated morphological types. However, this should be proven experimentally by inoculating banana plants separately with each morphological variant to study their reactions. Once this is proven it will be necessary to find the answer to questions such as what factors affect the frequency of variants and how these factors can be handled to regulate pathogenic populations of *R. similis.*

These experiments would confirm previous observations by the authors and help explain other important contributions by several authors in relation to the differences in losses, host range, lesion formation on root tissue and response to nematicide treatment in the different banana growing areas.

LITERATURE CITED

1. EDWARDS, D.I. and E.J. WEHUNT 1971. Host range of *Radopholus similis* from banana areas of Central America with indications of additional races. Pl. Dis. Rep. 55: 415-418.
2. JENKINS, W.R. 1964. A rapid centrifugal flotation techniques for separating nematodes from soil. Plant Dis. Rept. 48: 692.
3. MOODY, E.H., F.F. LOWNSBERY, and J.M. AHMED, 1973. Culture of the root-lesion nematode *Pratylenchus vulnus* on carrot disks. J. of Nematology 5 (3): 225-226.
4. PINOCHET, J. 1979. Comparison of four isolates of *Radopholus similis* from Central America on Valery bananas. Nematropica 9: 40-43.
5. TARTE, R. 1979;. Observaciones morfológicas de algunas variantes patogénicas de la raza del banano de *Radopholus similis. In* ACORBAT 79, Memorias de la IV Reunión. UPEB.
6. TOWNSHEND, J.L.; R. TARTE, and W.F. MAI, 1978. Growth response of three vegetables to smooth-and crenate-tailed females of three species of *Pratylenchus.* J. of Nematology 10 (3): 259-263.