

RELATIONSHIP BETWEEN HEIGHT OF KENAF AND ROOT GALLING BY *MELOIDOGYNE INCOGNITA*<sup>1</sup>

R. McSorley and J. L. Parrado

Respectively, Department of Entomology and Nematology, IFAS, University of Florida, Gainesville, Florida 32611; and Tropical Research and Education Center, Homestead, Florida 33031, U.S.A.

Accepted:

13.X.1986

Aceptado:

## RESUMEN

McSorley, R., y J. L. Parrado. 1986. Relación entre la altura del kenaf y la nodulación de las raíces por *Meloidogyne incognita*. Nematropica 16:205-211.

Datos de un experimento de campo relacionando la altura de la planta de kenaf (*Hibiscus cannabinus*) con la densidad de las masas de huevecillos y nódulos en el sistema radicular causados por el *Meloidogyne incognita* (raza 1) mostraron una correlación significativa ( $P < 0.01$ , 154 d.f.) con  $r = 0.575$ . Los datos agrupados por clases de densidad dieron un valor mejorado y altamente significativo ( $P < 0.01$ ), que se ajusta a los modelos lineales, cuadráticos y de Seinhorst con valores para  $r^2$  de 0.851, 0.905 y 0.877 respectivamente cuando se utilizaron los promedios de las clases de densidad. Las ecuaciones correspondientes relacionando la altura de la planta en cm (Y) con la densidad del nematodo (X), ( $X = \log_2(P+1.0)$ ) y  $P =$  numero de nódulos y masas de huevecillos/sistema radicular), fueron  $Y = 143.8-5.753X$ ,  $Y = 136.6-0.489X-0.587X^2$ , y  $Y/132.5 = 0.525 + 0.475 \times 0.996^{(X-10)}$ , para los modelos lineales, cuadráticos y de Seinhorst respectivamente. Cuando se sopesaron las observaciones de cada clase de densidad, el ajuste a los modelos lineales y cuadráticos fue similar al obtenidos con los datos no sopesados, pero disminuyó en valor para el modelo Seinhorst ( $r^2 = 0.774$  vs  $r^2 = 0.877$ ).

Palabras claves adicionales: funciones de daño, relación huésped-parasito, nematodo nodulador de las raíces, *Hibiscus cannabinus*.

---

Kenaf (*Hibiscus cannabinus* L.) is grown throughout the tropics and subtropics as a fiber crop (15). It is grown locally in southern Florida for use as support poles in pole bean (*Phaseolus vulgaris* L.) production (22). Root-knot nematodes (*Meloidogyne* spp.) are a common problem of kenaf in a number of locations throughout the world (11,12,14,18,21,24). Therefore it is important to understand the extent of yield loss in kenaf as a result of damage by root-knot nematode species. The objective of this study was to relate yield in terms of plant height to densities of *Meloidogyne incognita* (Kofoid and White) Chitwood galls and egg masses in roots using field data. Expression of such relationships had been hampered by the variability present in the field data, and only by using methods recently developed by Ferris (2) could clear trends be visually observed.

Seed of mixed kenaf cultivars was broadcast at a rate of 4.54 kg over a 0.305 ha area on June 3, 1981 to give an average plant density of 43/m<sup>2</sup>. The site was a Rockdale fine sandy loam soil (5) located in Home-

stead, Florida, previously planted to okra (*Abelmoschus esculentus* [L.] Moench.) and having an uneven infestation of *M. incognita*, identified as race 1 using a differential host test (20). A total of 26 plots, each 6.1m x 9.2m = 56m<sup>2</sup>, were established within the field. Preplant soil samples were collected from each plot and processed for nematodes by sieving and centrifugation (6). On August 5-6, six plants were chosen at random and harvested from each plot. A measurement of plant height in cm was made for each plant and the total number of *M. incognita* egg masses and galls on each corresponding root system was counted as a measure of nematode infection per plant.

All data points (nematode density, plant height) were arranged in a series of arbitrary density classes, using the same class intervals described by Ferris (2), *i.e.*, density class *i* ranging from between nematode densities of  $2^{(i-0.5)}$  and  $2^{(i+0.5)}$ . The number of observations per density class differed, and the mean nematode density and mean plant height were calculated from the observations for each respective density class. Mean nematode densities were transformed by  $\log_2$  (number of galls and egg masses + 1.0), and relationships between mean yield and mean nematode density developed using a computer program (3) for fitting Seinhorst's (19) function to experimental data. Goodness of fit to linear and quadratic models was also attempted (4). For each of the three models, analyses were attempted for two scenarios: in one case, curve fitting was done on the interval means alone (equal weight), while in the other case the data set was first weighted by the number of observations in each density class (2,4).

Preplant soil counts of *M. incognita* juveniles were low (<10/100 cm<sup>3</sup> soil) in all plots. However, preplant soil counts taken during the summer have since been shown to be extremely unreliable in anticipating subsequent crop damage on these soils (8,9). Despite the low preplant densities, stunting occurred in uneven patches in the field. Severely stunted plants were yellow and some exhibited signs of severe iron deficiency, characterized by reddish foliage at the tips of the stems.

When all 156 data points (plants) were considered individually, a relatively weak, but statistically significant ( $P < 0.01$ , 154 d.f.), linear correlation was found between plant height and  $\log_2$  (nematode density + 1.0), with  $r^2 = 0.331$  (Table 1). Much variation was apparent in the measured plant heights, some apparently due to nematodes, but much also due to effects such as plant spacing or genotypic variation of the individual plants. Relatively weak, but significant ( $P < 0.01$ ) fits to quadratic and Seinhorst models were also noted for the unpooled data, with  $r^2$  ranging from 0.328 to 0.338 (Table 1). Grouping of the data into density classes provided much stronger relationships between plant heights and nematode density (Table 1).

Table 1. Goodness of fit of kenaf data to selected models.

Model	Data not pooled into density class	Data pooled into 10 density classes	
		Not weighted <sup>z</sup>	Weighted <sup>z</sup>
Linear	Y=141.5-4.804X r <sup>2</sup> =0.331**	Y=143.8-5.753X r <sup>2</sup> =0.851**	Y=141.3-4.734X r <sup>2</sup> =0.870**
Quadratic	Y=139.3-2.531X-0.294X <sup>2</sup> r <sup>2</sup> =0.338***	Y=136.6-0.489X-0.587X <sup>2</sup> r <sup>2</sup> =0.905**	Y=139.1-2.468X-0.292X <sup>2</sup> r <sup>2</sup> =0.886**
Seinhorst	Y/131.4=0.628+0.372x0.993 <sup>(1-t)</sup> r <sup>2</sup> =0.328**	Y/132.5=0.525+0.475x0.996 <sup>(1-t)</sup> r <sup>2</sup> 0.877**	Y/134.2=0.630+0.370x0.994 <sup>(1-t)</sup> r <sup>2</sup> 0.774**

<sup>z</sup>Weighted=data set weighted by number of observations in each density class. Y=plant height in cm; P=number of egg masses and galls per root system; X=log<sub>2</sub> (P+1.0). Asterisks (\*\*\*) indicate significant r<sup>2</sup> at probability level < 0.01.

Three models are compared to the unweighted means of the various density classes in Fig. 1. Although various typical shapes have been ascribed to nematode damage functions (13,19,23), the linear, quadratic, and Seinhorst models all provided similar good fits to the experimental data. In this example, the Seinhorst relationship suggests a tolerance level, T, of 8.0 galls and egg masses per root system ( $\log_2 [8.0 + 1.0] = 3.17$ ), with a maximum height of 132.5 cm at densities less than 8.0. Values above  $X=5.0$  ( $P=31$ ) fit the Seinhorst relationship more closely than the other models. In this region of the data set, vertical deviations of fitted curves summed to 16.9, 24.5, and 41.5 units for the Seinhorst, quadratic, and linear models, respectively. When the data sets were weighted by the number of observations in each, fits of the linear and quadratic models were similar to the unweighted data sets (Table 1), but the fit to the Seinhorst model, though highly significant, was not as good as for the unweighted data set ( $r^2=0.774$  vs  $r^2=0.877$ ). Still, use of weighted data sets avoids the bias introduced in the unweighted data sets, in which equal weight is given to density classes having few or many observations.

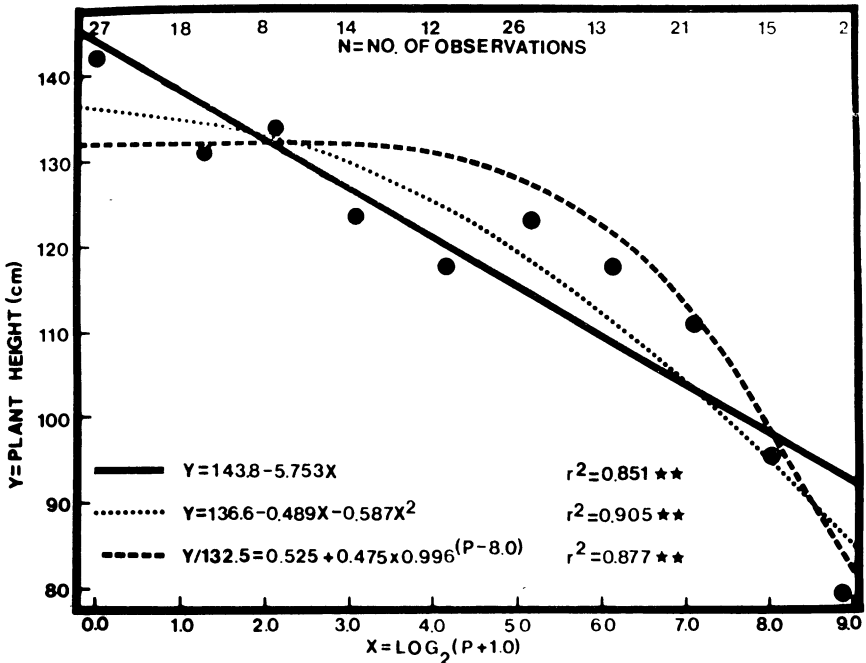


Fig. 1. Goodness of fit of three models to experimental data averaged by *Meloidogyne incognita* density classes. The data set was not weighted by the number of observations (N) per density class. P=number of eggmasses and galls per root system.

In comparing the coefficients of determination ( $r^2$ ) for relationships developed from pooled data vs. unpooled data (Table 1), it is evident that much improved fits to the three models were achieved by grouping data into density classes prior to model fitting. Pooling into density classes is achieved at the expense of degrees of freedom, however, since 156 points were available for curve fitting in the original data set, but only 10 points were available once data had been grouped into density classes. The implication of pooling data prior to hypothesis testing is unclear; while  $r^2$  increases with pooling, degrees of freedom decrease, with the result that significance levels may remain similar in both cases. It is evident, however, that the greater  $r^2$  values achieved by pooling will make it much easier to visualize trends in data sets, if curve fitting rather than hypothesis testing is the ultimate objective.

The methodology proposed by Ferris (2) was particularly useful in developing damage functions from plant height data which were highly variable. The results illustrate that in this example using field data, the three alternative models—Seinhorst, quadratic, and linear—all fit the experimental data set reasonably well. Although Seinhorst's relationship has usually been used with preplant nematode densities (2,19), it apparently also has some application when nematode densities are measured at later stages of crop growth. This may be of particular interest in systems in which preplant soil counts are unreliable, as for *Meloidogyne* spp. in some cases (9), or in certain long-lived crops, such as cassava, in which the correlation between plant yield and nematode density increases as counts are taken later in the season (8). Relationships between plant damage and post-plant or final nematode populations may not always be as apparent as that presented here. It is well known that populations may decline following severe root damage (1,16), and in such situations, points exhibiting low yield with low nematode populations will appear in the data set, contradicting models in which low yield with high populations are anticipated. The dynamic nature of nematode population growth suggests that the relationship of plant growth to nematode density may vary over time, in addition to being a function of the system (host, growing conditions, soil type, etc.) involved. There is increasing evidence that, in some systems, plant damage may show a stronger correlation with post-plant or final populations than with initial densities (8,10,17). This is not to imply that relationships between yield and initial density do not exist in such systems, but rather they are more difficult to discern, either because of problems in detection (9,17) or increased sampling error at low densities (7).

The experimental data presented here illustrate the potential for serious damage to kenaf by high *M. incognita* populations, particularly at the highest densities where a minimum yield of only 52% of

maximum was predicted from Seinhorst's equation using the unweighted data set.

#### LITERATURE CITED

1. BARKER, K. R., and C. J. NUSBAUM. 1971. Diagnostic and advisory programs. Pp. 281-301 in B. M. Zuckerman, W. F. Mai, and R. A. Rohde (eds.), *Plant Parasitic Nematodes*. Vol. I. Academic Press, New York. 345 pp.
2. FERRIS, H. 1984. Nematode damage functions: the problems of experimental and sampling error. *J. Nematol.* 16:1-9.
3. FERRIS, H., W. D. TURNER, and L. W. DUNCAN. 1981. An algorithm for fitting Seinhorst curves to the relationship between plant growth and preplant nematode densities. *J. Nematol.* 13:300-304.
4. FREUND, R. J., and R. C. LITTELL. 1981. SAS for linear models. SAS Institute Inc., Cary, NC. 231 pp.
5. GALLATIN, M. H., J. K. BALLARD, C. B. EVANS, H. S. GALLBERRY, J. J. HINTON, D. P. POWELL, E. TRUETT, W. L. WATTS, G. C. WILSON, Jr., and R. G. LEIGHTY. 1958. Soil survey (detailed-reconnaissance) of Dade County, Florida. U.S. Government Printing Office, Washington. 56 pp.
6. JENKINS, W. R. 1964. A rapid centrifugal-flotation technique for separating nematodes from soil. *Plant Dis. Reprtr.* 48:692.
7. MCSORLEY, R., and J. L. PARRADO. 1982. Estimating relative error in nematode numbers from single soil samples composed of multiple cores. *J. Nematol.* 14:522-529.
8. MCSORLEY, R., and J. L. PARRADO. 1985. Relative performance of two cassava cultivars in a field infested with *Meloidogyne incognita*. *Soil Crop Sci. Soc. Fla. Proc.* 44:180-183.
9. MCSORLEY, R., and K. POHRONEZNY. 1981. A simple bioassay as a supplement to soil extraction for detection of root knot nematodes. *Soil Crop Sci. Soc. Fla. Proc.* 40:121-123.
10. MCSORLEY, R., K. POHRONEZNY, and W. M. STALL. 1981. Aspects of nematode control on snap bean with emphasis on the relationship between nematode density and plant damage. *Proc. Fla. State Hort. Soc.* 94:134-136.
11. MINTON, N. A., and W. C. ADAMSON. 1979. Control of *Meloidogyne javanica* and *M. arenaria* on kenaf and roselle with genetic resistance and nematicides. *J. Nematol.* 11:37-41.
12. MINTON, N. A., W. C. ADAMSON, and G. A. WHITE. 1970. Reaction of kenaf and roselle to three root knot nematode species. *Phytopathology* 12:1844-1845.

13. OOSTENBRINK, M. 1966. Major characteristics of the relation between nematodes and plants. Meded. Landbouw. Wageningen 66(4):1-46.
14. PARRADO, J. L. 1958. Diseases of kenaf in Cuba. Pp. 113-123 in Proceedings of the World Conference on Kenaf. International Cooperation Administration, Washington. 288 pp.
15. PURSEGLOVE, J. W. 1977. Tropical crops. Dicotyledons. Longman Group Ltd., London. 719 pp.
16. RICKARD, D. A., and K. R. BARKER. 1982. Nematode assays and advisory services. Pp. 8-20 in R. D. Riggs (ed.), Nematology in the Southern Region of the United States. Southern Cooperative Series Bulletin 276, Fayetteville, AR. 206 pp.
17. RODRIGUEZ-KABANA, R., C. F. WEAVER, D. G. ROBERTSON, and E. L. SNODDY. 1986. Population dynamics of *Meloidogyne arenaria* juveniles in a field with Florunner peanut. Nematropica 16:185-196.
18. SCHIEBER, E., O. N. SOSA, and P. ESCOBAR. 1961. Root-knot nematode on kenaf in Guatemala. Plant. Dis. Repr. 45:119.
19. SEINHORST, J. W. 1965. The relation between nematode density and damage to plants. Nematologica 11:137-154.
20. TAYLOR, A. L., and J. N. SASSER. 1978. Biology, identification and control of root-knot nematodes (*Meloidogyne* species). North Carolina State University Graphics, Raleigh. 111 pp.
21. TU, C. C., and Y. H. CHENG. 1971. Interaction of *Meloidogyne javanica* and *Macrophomina phaseoli* in kenaf root rot. J. Nematol. 3:39-42.
22. WADDILL, V., K. POHRONEZNY, R. MCSORLEY, and H. H. BRYAN. 1984. Effect of manual defoliation on pole bean yield. J. Econ. Entomol. 77:1019-1023.
23. WALLACE, H. R. 1973. Nematode ecology and plant disease. Edward Arnold, London. 215 pp.
24. WILSON, F. D., and T. E. SUMMERS. 1966. reaction of kenaf, roselle and related species of *Hibiscus* to root-knot nematodes. Phytopathology 56:687-690.

*Received for publication:*

3.IX.1986

*Recibido para publicar:*