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NEMATODE POPULATION DENSITY INCREASE ON COVER CROPS OF RYE AND VETCH[1]

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ABSTRACT

McSorley, R., and D. W. Dickson. 1989. Nematode population density increase on cover crops of rye and vetch. Nematrópica 19:39–51.

Population densities of plant-parasitic nematodes were monitored for two seasons in plots with winter cover crops of rye (*Secale cereale*) or hairy vetch (*Vicia villosa*) on sandy soils in north central Florida. The ranges in nematode densities observed in the plots permitted derivation of linear relationships between final population densities (Pf) after 3 and 5 months and initial population densities (Pi) before planting of cover crops in October or November. More consistent linear relationships ($P \leq 0.05$) were obtained for *Belonolaimus longicaudatus* and *Criconemella sphaerocephala* than for *Meloidogyne incognita* and *Pratylenchus brachyurus*. In most instances, population densities were maintained by the cover crops, with Pf ≈ Pi. However, maintenance of a rye cover crop for almost 5 months resulted in increased *B. longicaudatus* densities, with Pf ≈ 2 Pi or 3 Pi, depending on the season.

Key words: Belonolaimus longicaudatus, cover crops, *Criconemella sphaerocephala,* crop rotation, cropping system, *Meloidogyne incognita,* population dynamics, *Pratylenchus brachyurus,* rye, *Secale cereale,* vetch, *Vicia villosa.*

RESUMEN

McSorley, R., y D.W. Dickson. 1989. Incremento en los niveles de las poblaciones de nematodes en cultivos de cobertura como centeno y vizia. Nematrópica 19:39–51.

Los niveles de la población de nematodos fitoparasíticos se estudiaron durante dos años en parcelas con cultivos de cobertura como el centeno (*Secale cereale*) y vizia (*Vicia villosa*). El estudio se llevo a cabo en suelos arenosos en la parte central del norte de la Florida. Los rangos obtenidos en los niveles de población permitieron la derivación de una relación linear entre el nivel final de la población (Pf) después de 3 o 5 meses y el nivel inicial (Pi) antes de plantar los cultivos de cobertura en Octubre o en Noviembre. Se obtuvo una relación linear más consistente ($P \leq 0.05$) con *Belonolaimus longicaudatus* y con *Criconemella sphaerocephala* que con *Meloidogyne incognita* o con *Pratylenchus brachyurus*. En la mayoría de los casos, los niveles de la población de nematodos se mantuvieron en los cultivos de cobertura con Pf ≈ Pi. Sin embargo, después de 5 meses de utilizar el centeno como cultivo de cobertura, se observó un incremento en los niveles de población de *B. longicaudatus* con Pf ≈ 2 Pi o 3 Pi, según la época del año.

Palabras claves: Belonolaimus longicaudatus, centeno, *Criconemella sphaerocephala,* cultivo de cobertura, dinámica de población, *Meloidogyne incognita, Pratylenchus brachyurus,* rotación de cultivos, *Secale cereale,* sistema de cultivos, *Vicia villosa.*

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INTRODUCTION

Crop rotation is an effective method for managing populations of certain species of plant-parasitic nematodes below damaging levels (1, 8,12,13,16,26). In cooler regions, crop rotation often is interpreted as a different crop in each of two or more successive years, but in tropical and subtropical regions, multiple cropping and complicated rotations within the same year are typical (1,10,13,16). In continuous tropical and subtropical cropping patterns, the individual crops can be viewed as components in the overall cropping system (16,26). Nematode population increase or decrease in such systems could be estimated by a sequence of critical point models estimating final (Pf) from initial population densities (Pi) for each of a series of successive crops (5,6). To implement cropping systems effective in reducing nematode numbers and damage, it is evident that detailed data are required on nematode population increase or decrease on each component crop utilized in a parcticular region (16).

In Florida and other parts of the southeastern United States, continuous cropping is possible, but quite often the growing season may consist of one major economic crop and a cover crop of lesser value. Cover crops avoid the disadvantages of fallow (20) and may provide additional income when harvested or grazed for pasture. Weeds also should be regarded as cover crops when considering possible nematode multiplication (14,19). Cover crops are extensively used in the southeastern United States, and the effects of certain cover crops on nematode population densities are well documented (2,8,9,12,14,15,18–20). The current study was conducted to determine the increase in nematode population densities under field conditions in hairy vetch (*Vicia villosa* Roth) and rye (*Secale cereale* L.), two winter cover crops grown frequently in rotation with summer agronomic crops in the southeastern United States (21–23).

MATERIALS AND METHODS

Experimental plots were established in October 1986 at the University of Florida Agronomy Farm near Jonesville in Alachua County. The soil type was an Arredondo fine sand (95.8% sand, 1.8% silt, 2.4% clay, 1.2% organic matter, pH 6.0), and the 2.0–ha site had been planted to maize (*Zea mays* L.) for several years previously. On 31 October, seed of hairy vetch inoculated with *Rhizobium leguminosarum* (Frank) Frank was drilled over half the area in 15-cm rows at a rate of 68 kg/ha. The remaining half of the site was planted with 50 kg/ha of 'Wrens Abruzzi' rye on 7 November. Before planting, 16 permanent 3 m × 3 m square plots were established in each crop. One-half of the vetch plots and one-half of the rye plots were disked in early February 1987 in preparation for planting of maize. The remaining vetch and rye plots were maintained until early April, when they were mowed and disked before planting soybean (*Glycine max* (L.) Merr.). No fertilizers or pesticides were used on the vetch and rye cover crops. Similar procedures were used during the winter of 1987–88, except that the planting date for each cover crop was 12 November 1987.

Soil samples for nematode analysis were collected from all 16 vetch plots on 27 October 1986 and 27 January 1987, and on 1 April 1987 from the eight vetch plots remaining on that date. Corresponding dates for collecting samples from rye plots were 7 November 1986, 3 February 1987, and 1 April 1987. During the following season, samples were collected from all vetch and rye plots on 12 November 1987 and 1 February 1988, and from the remaining eight plots of each crop on 28 March 1988.

Individual soil samples consisted of 12 cores, 20 cm deep, collected in a stratified random pattern with a sampling core (4). Three replicate samples were collected from each 3 m × 3 m plot on each sampling date. Nematodes were extracted from each sample by a modified sieving-centrifugation technique (11). A 100-cm^3 soil subsample from each of the three samples collected per plot was extracted and counted. The counts from the three replicate samples per plot were then averaged to obtain an estimate of mean nematode population density/100 cm^3 of soil for that plot. Root material collected with the soil cores was removed, chopped in a blender, and incubated on Baermann trays for 48 hours for recovery of endoparasitic nematodes.

Before data analysis, all nematode population densities were transformed by $\log_2$ (density + 1). Pearson product-moment correlation coefficients (25) were computed between (Pi) and (Pf) of each nematode on each host during each season (1986–87 or 1987–88). These coefficients were computed between Pi and a Pf measured on each of two different dates (Pf3 = samples collected in late January or early February, about 3 months after Pi; Pf5 = samples collected in late March or early April, about 5 months afer Pi). Based on 16 plots, Pf3 would be a typical Pf for the cover crop if maize were to be planted in late February or early March, which is normal for north central Florida. Based on eight plots, Pf5 would be an appropriate Pf for the cover crop if soybean were to be planted in May or early June, which is typical of north central Florida. Significant ($P \leq 0.05$) correlations were further examined via linear or quadratic regression analysis (7) of final population densities (Pf3 or Pf5) on Pi.

RESULTS AND DISCUSSION

A range in densities of *Belonolaimus longicaudatus* Rau, *Meloidogyne*

Table 1. Nematode densities in soil taken from plots of either rye or vetch cover crops over two seasons.

Host and nematode	1986–87 season[z]			1987–88 season[z]		
	Pi (October–November)	Pf3 (January–February)	Pf5 (April)	Pi (November)	Pf3 (February)	Pf5 (March)
Rye						
Belonolaimus longicaudatus	0.7 ± 0.3	5.3 ± 2.2	7.1 ± 4.5	3.2 ± 1.2	3.4 ± 1.3	7.0 ± 4.2
Criconemella sphaerocephala	42.9 ± 11.5	73.2 ± 24.0	79.7 ± 24.8	49.1 ± 17.6	68.3 ± 26.7	22.2 ± 10.4
Meloidogyne incognita	13.1 ± 2.5	7.6 ± 3.0	0.1 ± 0.05	3.5 ± 1.4	3.7 ± 2.8	0.1 ± 0.1
Pratylenchus brachyurus	80.5 ± 10.4	48.8 ± 5.9	22.6 ± 5.8	64.4 ± 12.0	36.2 ± 6.2	18.4 ± 6.5
Paratrichodorus minor	1.0 ± 0.2	0	0	0.3 ± 0.1	0.5 ± 0.2	0.2 ± 0.2
Xiphinema sp.	0	0	0	0.1 ± 0.05	2.1 ± 1.5	2.3 ± 1.3
Vetch						
Belonolaimus longicaudatus	1.3 ± 0.4	3.3 ± 0.9	5.4 ± 2.1	5.0 ± 2.0	3.2 ± 1.0	2.5 ± 1.0
Criconemella sphaerocephala	33.9 ± 10.2	44.4 ± 18.0	34.7 ± 22.4	38.3 ± 13.4	38.7 ± 14.6	28.5 ± 15.4
Meloidogyne incognita	19.0 ± 11.0	18.8 ± 12.6	0.5 ± 0.3	16.3 ± 8.2	7.1 ± 5.7	1.7 ± 0.7
Pratylenchus brachyurus	61.6 ± 10.0	53.4 ± 9.7	30.3 ± 9.5	95.0 ± 22.8	43.1 ± 12.1	18.8 ± 5.0
Paratrichodorus minor	2.7 ± 0.5	0	0	0.2 ± 0.1	0.3 ± 0.2	0.3 ± 0.2
Xiphinema sp.	0	0	0	0.2 ± 0.1	0.2 ± 0.2	<0.1

[z] Mean ± standard error of nematode density/100 cm^3 of soil over 16 plots (Pi, Pf3) or 8 plots (Pf5).

incognita (Kofoid & White) Chitwood, *Pratylenchus brachyurus* (Godfrey) Filipjev & Schuurmans Stekhoven, *Criconemella sphaerocephala* (Taylor) Luc & Raski, *Paratrichodorus minor* (Colbran) Siddiqi, and a *Xiphinema* species (possibly *X. floridae* Lamberti & Bleve-Zacheo) was found in both rye and vetch plots (Table 1). Occasionally, individuals of a *Hoplolaimus* species also were found.

This experiment was designed to provide a wide range of nematode densities to facilitate development of models relating Pf and Pi (24). It was not designed to make statistical comparisons between rye and vetch as nematode hosts, because all rye plots occurred within a large rye field, and were not paired with vetch plots and randomized over a range of locations. Comparison of densities within the rye field with those in the vetch field by means of a *t*-test revealed differences ($P \leq 0.05$) in *Xiphinema* sp. densities in February and March 1988, between *M. incognita* densities in March 1988, and between *C. sphaerocephala* densities in January/February and in April 1987. Although these results support the hypothesis that growth of different hosts resulted in differences in nematode densities, the alternative hypothesis that differences resulted from location effects cannot be rejected, due to the experimental design used.

For the four most abundant nematodes, linear relationships ($P \leq 0.05$) were found between Pf and Pi on each cover crop (Table 2). More consistent relationships were noted for the ectoparasites *B. longicaudatus* and *C. sphaerocephala* than for the endoparasites *M. incognita* and *P. brachyurus*. Pf values based on soil counts alone are expected to be somewhat less quantitative for endoparasites than for ectoparasites; however, recovery of *M. incognita* and *P. brachyurus* from roots was negligible. In some instances, quadratic models provided ($P \leq 0.05$) improvement in r^2 values over corresponding linear models (Table 3). Linear and quadratic regresion models are compared using *C. sphaerocephala* data as an example (Fig. 1). It should be emphasized that, although these models may provide excellent fits within the range of Pi values observed in the data set, generalizations outside of the Pi range are risky, particularly with quadratic models. For example, at a Pi of 511 $\log_2(x + 1) = 9$, the quadratic relationship depicted in Figure 1 predicts a Pf $> 85\,000$ nematodes/100 cm^3 of soil, an unlikely field population!

A comparison of all the linear regression models for *B. longicaudatus* population density increase (Table 2) revealed several interesting trends (Fig. 2). For the same crop and season, greater final densities were obtained on the cover crop after about 5 months (Pf5) than after 3 months (Pf3). On each crop, higher final densities were reached in the 1986–87 season than in 1987–88, which was not unexpected in view of the many factors that could cause seasonal variation in multiplication rates (6). Within the same season, higher final densities of *B. lon-*

Table 2. Relationship between initial (Pi) and final (Pf) densities of four nematode species on two hosts during two winter seasons.

Nematode	Host	Season	x	y	r^2	Linear regression equation[z]
Belonolaimus longicaudatus	Rye	1986–87	Pi[y]	Pf3[y]	0.342*	$y = 0.602 + 1.365x$
	Rye	1986–87	Pi	Pf5	0.806**	$y = 0.522 + 2.844x$
	Rye	1987–88	Pi	Pf3	0.852***	$y = 0.031 + 0.968x$
	Rye	1987–88	Pi	Pf5	0.858***	$y = 0.249 + 1.786x$
	Vetch	1986–87	Pi	Pf3	0.609***	$y = 0.396 + 1.207x$
	Vetch	1986–87	Pi	Pf5	0.422	$y = 1.041 + 1.201x$
	Vetch	1987–88	Pi	Pf3	0.811***	$y = 0.180 + 0.775x$
	Vetch	1987–88	Pi	Pf5	0.931***	$y = 0.048 + 0.980x$
Criconemella sphaerocephala	Rye	1986–87	Pi	Pf3	0.835***	$y = -0.962 + 1.247x$
	Rye	1986–87	Pi	Pf5	0.866***	$y = 0.810 + 0.937x$
	Rye	1987–88	Pi	Pf3	0.578***	$y = 1.536 + 0.748x$
	Rye	1987–88	Pi	Pf5	0.422	$y = 1.844 + 0.542x$
	Vetch	1986–87	Pi	Pf3	0.739***	$y = -2.317 + 1.332x$
	Vetch	1986–87	Pi	Pf5	0.795**	$y = -0.621 + 1.056x$
	Vetch	1987–88	Pi	Pf3	0.804***	$y = 0.498 + 0.887x$
	Vetch	1987–88	Pi	Pf5	0.776**	$y = 0.275 + 0.896x$
Meloidogyne incognita	Rye	1986–87	Pi	Pf3	0.270*	$y = 0.296 + 0.656x$
	Rye	1986–87	Pi	Pf5	NS	—
	Rye	1987–88	Pi	Pf3	NS	—
	Rye	1987–88	Pi	Pf5	NS	—
	Vetch	1986–87	Pi	Pf3	0.881***	$y = -0.018 + 0.944x$
	Vetch	1986–87	Pi	Pf5	NS	—
	Vetch	1987–88	Pi	Pf3	0.569***	$y = 0.170 + 0.536x$
	Vetch	1987–88	Pi	Pf5	0.522*	$y = 0.315 + 0.288x$

Pratylenchus brachyurus	Rye	1986–87	Pi	Pf3	0.720***	$y = 0.791 + 0.762x$
	Rye	1986–87	Pi	Pf5	NS	—
	Rye	1987–88	Pi	Pf3	0.188	$y = 1.651 + 0.541x$
	Rye	1987–88	Pi	Pf5	0.712**	$y = 0.396 + 0.628x$
	Vetch	1986–87	Pi	Pf3	0.889***	$y = -1.029 + 1.126x$
	Vetch	1986–87	Pi	Pf5	NS	—
	Vetch	1987–88	Pi	Pf3	NS	—
	Vetch	1987–88	Pi	Pf5	0.700**	$y = 1.112 + 0.509x$

[y] $x = \log_2(\text{Pi} + 1)$ or $y = \log_2(\text{Pf3} + 1)$ or $y = \log_2(\text{Pf5} + 1)$. Pi = nematodes/100 cm^3 of soil measured in October–November. Pf3 = nematodes/100 cm^3 of soil measured in January–February. Pf5 = nematodes/100 cm^3 of soil measured in March–April.

[z] Dashes (—) indicate regression equation not derived. Asterisks (*, **, ***) for r^2 values indicate significant relationships at $P \leq 0.05$, $P \leq 0.01$, and $P \leq 0.001$, respectively. Values of r^2 significant at $P \leq 0.10$ are unmarked; NS = not significant.

Table 3. Quadratic relationships between initial (Pi) and final (Pf) nematode densities which provided significant ($P \leq 0.05$) increases in r^2 over corresponding linear models.

Nematode	Host	Season	x	y	r^2	Quadratic regression equation
Belonolaimus longicaudaus	Rye	1986–87	Pi[y]	Pf3[y]	0.706***[z]	$y = 0.338 + 6.958x - 3.181x^2$
	Rye	1986–87	Pi	Pf5	0.934***	$y = 0.402 + 7.823x - 3.152x^2$
	Vetch	1987–88	Pi	Pf5	0.978***	$y = 2.205x - 0.462x^2$
Criconemella sphaerocephala	Vetch	1986–87	Pi	Pf3	0.862***	$y = 3.580 - 1.893x - 0.369x^2$
Meloidogyne incognita	Rye	1986–87	Pi	Pf3	0.648**	$y = 2.391 - 2.433x + 0.578x^2$
	Vetch	1986–87	Pi	Pf3	0.835*	$y = 0.488 - 0.562x + 0.103x^2$

[y] $x = \log_2$ (Pi + 1) or $y = \log_2$ (Pf3 + 1) or $y = \log_2$ (Pf5 + 1). Pi = nematodes/100 cm^3 of soil, measured in October–November. Pf3 = nematodes/100 cm^3 of soil, measured in January–February. Pf5 = nematodes/100 cm^3 of soil measured in March–April.

[z] Asterisks (*, **, ***) indicate significant r^2 values at $P \leq 0.05$, $P \leq 0.01$, and $P \leq 0.001$, respectively.

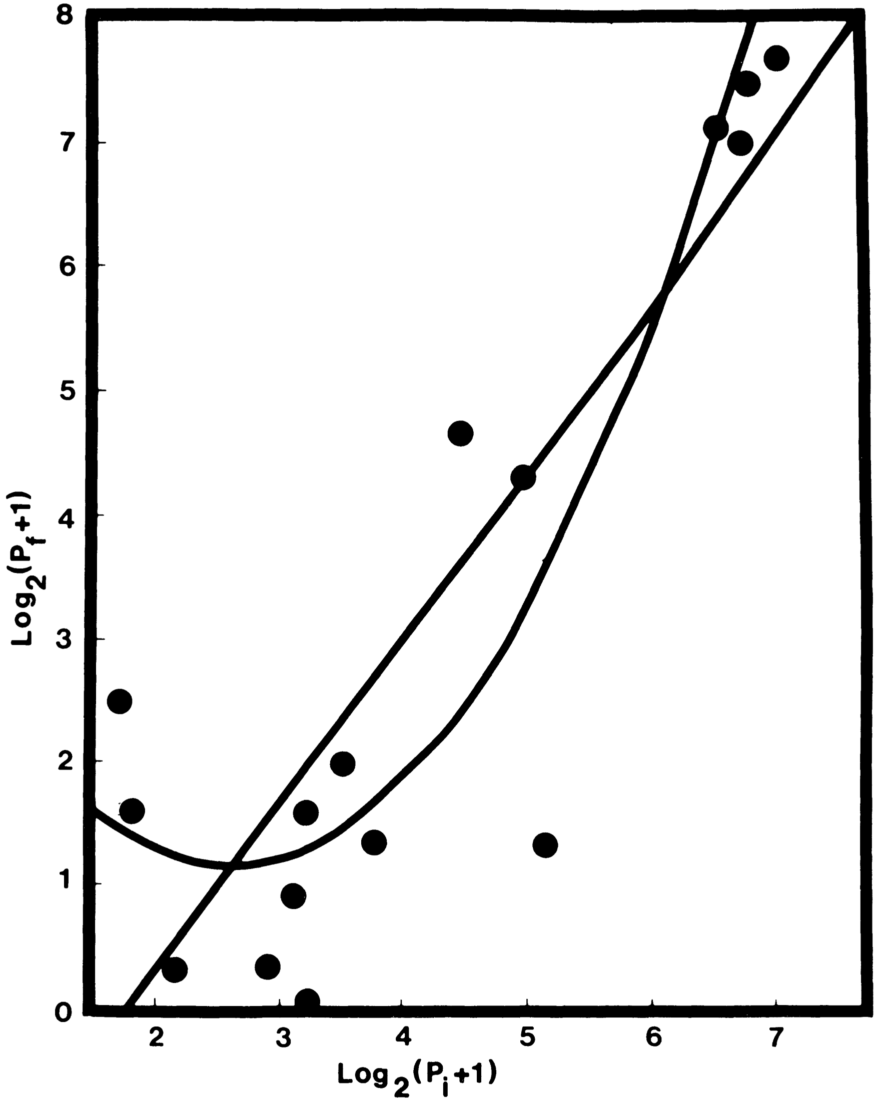

Fig. 1 Relationship between initial population ([$x = \log_2$ (Pi + 1)], measured October 1986) and final population density ([$y = \log_2$ (Pf3 + 1)], measured January 1987) of *Criconemella sphaerocephala* on a vetch cover crop. Linear equation: $y = -2.317 + 1.332x$, $r^2 = 0.739$; quadratic equation: $y = 3.580 - 1.893x - 0.369x^2$, $r^2 = 0.862$.

gicaudatus were reached on rye than on vetch. Final densities of *B. longicaudatus* were particularly high if the rye crop was allowed to grow for almost 5 months. The slope values for Pf5 on rye of 1.786 (1987–88) and 2.844 (1986–87) are much greater than 1.0, suggesting a near doubling or tripling of *B. longicaudatus* on the cover crop (Fig. 2).

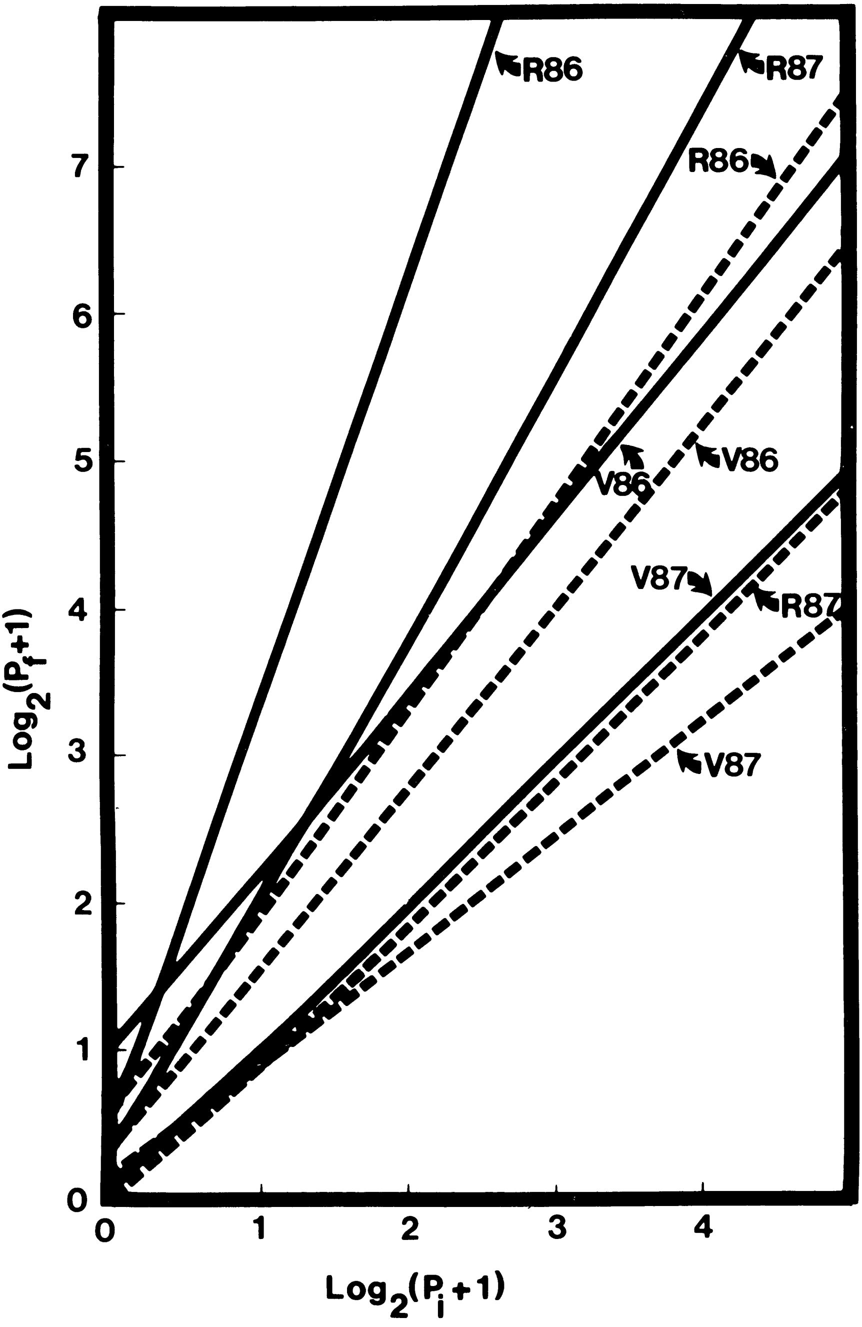

Fig. 2. Relationships between initial population (Pi, measured October–November) and final population density of *Belonolaimus longicaudatus* (solid line = $\log_2$ (Pf5 + 1), measured March–April; dashed line = $\log_2$ (Pf3 + 1), measured January–February). V86 = vetch, 1986–87 season; V87 = vetch 1987–88 season; R86 = rye, 1986–87 season; R87 = rye, 1987–88 season. Regression equations given in Table 2.

Growth either of rye for about 3 months or of vetch for 5 months in 1987–88 resulted in maintenance of the *B. longicaudatus* population during the cover crop season, with Pf ≈ Pi (Fig. 2).

All of the linear relationships between Pf and Pi for *C. sphaerocephala* (Table 2) also would cluster around the maintenance line with Pf ≈ Pi since most slopes were near or slightly below 1.0. Similarly, the slopes of significant equations for *M. incognita* and *P. brachyurus* were near 1.0 or below (Table 2), suggesting that these nematodes would maintain their numbers during cover cropping, or would decline in some instances. In a previous study (17), *M. incognita* and other *Meloidogyne* spp. declined on a winter crop of 'Wrens Abruzzi' rye in microplots, with Pf/Pi = 0.38 or less.

In summary, winter cover cropping with vetch or rye under our conditions approximately maintained population densities of three of the four most common nematodes observed. In some instances, slight declines may even be anticipated, but in most cases a Pf ≈ Pi would be expected. It is possible that nematode populations following winter cover crops could be more vigorous and infective than if fallow had been maintained. Starvation and nonfeeding are known to reduce energy reserves (3), and this depletion during fallow could perhaps be reduced or avoided if cover crops are used.

Cover cropping to manage *B. longicaudatus* may be very difficult. Growth of vetch usually resulted in final population densities near the maintenance level, but densities somewhat above maintenance levels could occur in some seasons. Growth of rye resulted in increased *B. longicaudatus* densities, particularly if this cover crop was maintained for almost 5 months. Winter cover cropping with rye may be a poor practice for growers wishing to keep spring population levels of *B. longicaudatus* at or below those occurring in the fall, since this host provided an opportunity for increasing population densities up to two- or threefold during the "off season."

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