CHANGES IN POPULATION DENSITIES OF *MELOIDOGYNE* SPP. AND *PARATRICHODORUS MINOR* ON WINTER RYE COVER CROPS[†]

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ABSTRACT

McSorley, R. 1994. Changes in population densities of *Meloidogyne* spp. and *Paratrichodorus minor* on winter rye cover crops. Nematropica 24:151-160.

Field and microplot data collected over three seasons were used to determine relationships between initial (Pi) and final (Pf) population densities of *Meloidogyne* spp. and *Paratrichodorus minor* on winter cover crops of rye (*Secale cereale*) in north Florida. Log-transformed Pf and Pi were linearly related for *Meloidogyne arenaria* race 1 and *M. incognita* race 1. For data pooled across locations and seasons from sites at which *M. arenaria* predominated, the relationship between Pf and Pi was expressed by the equation $\log_e (Pf+1) = 0.863 \log_e (Pi+1) - 0.26$ ($r^2=0.863$; $P \leq 0.01$). This equation indicates that existing population densities of *M. arenaria* will be nearly maintained by a winter cover crop of rye, but without increasing above Pi levels. Pf of *P. minor* was linearly related to Pi for each site and season, but there was no consistent relationship across sites and seasons.

Key words: cover crops, crop rotation, *Meloidogyne arenaria*, *Meloidogyne incognita*, nematode management, *Paratrichodorus minor*, population dynamics, root-knot nematodes, *Secale cereale*, stubby-root nematodes.

RESUMEN

McSorley, R. 1994. Cambios en densidades de *Meloidogyne* spp. y *Paratrichodorus minor* en cultivos coberturas de centeno. Nematrópica 24:151-160.

Datos recolectados en campo y micro parcelas durante varias estaciones se utilizaron para determinar las relaciones entre las densidades poblacionales iniciales (Pi) y finales (Pf) de *Meloidogyne* spp. y *Paratrichodorus minor* en coberturas de invierno de centeno (*Secale cereale*) en el Norte de Florida. Las poblaciones finales de *P. minor* fueron linealmente relacionados a las poblaciones iniciales por cada sitio en la estación; pero no hubo una relación consistente entre sitios y estaciones. Los valores de Pf y Pi transformados logarítmicamente fueron linealmente relacionados en *Meloidogyne arenaria* raza 1 y *M. incognita* raza 1. Para los datos sacados entre localidades y estaciones de sitios en los cuales *M. arenaria* predominó, la relación entre Pf y Pi se expresó por medio de la ecuación $\log (Pf + 1) = 0.863 \log_e (Pi + 1) - 0.26$ ($r_2 = 0.863$; $P \leq 0.01$). Esta ecuación indica que las densidades poblaciones existentes de *M. arenaria* casi se mantendrán mediante una cobertura de invierno de centeno pero sin ser mayores que los niveles de Pi.

Palabras clave: coberturas, rotación de cultivos, *Meloidogyne arenaria*, *Meloidogyne incognita*, manejo de nematodos, *Paratrichodorus minor*, dinámica poblacional, nematodo agallador, *Secale cereale*.

INTRODUCTION

Crop rotation has been an effective method for managing plant-parasitic nematodes under a variety of field conditions (4,6,8,12-16,20,22). In the southeastern United States, winter cover crops can be very important in crop rotation systems and can affect nematode population densities and damage in subsequent cash crops (4,6,14,15). Rye (*Secale cereale* L.) is important as a winter cover crop for forage in Florida (18) and Georgia (7). *Belonolaimus longicaudatus* Rau increased on a winter rye crop, but *Meloidogyne incognita* (Kofoid and White) Chitwood declined to slightly less than preplant levels (10). In microplots with winter rye, *Meloidogyne* spp. declined to <40% of initial levels, although initial population densities were extremely high (>2,200/100 cm³ soil) (17). Rye is a poor host which supports some reproduction of *M. incognita, M. arenaria* (Neal) Chitwood, and *M. javanica* (Treub) Chitwood (7,17). Johnson and Motsinger (7) suggest that reproduction of *Meloidogyne* spp. on rye in the field may be limited by low winter temperatures. Regardless of its host status to *Meloidogyne* spp., winter rye appears to be preferable to highly susceptible legumes such as crimson clover (*Trifolium incarnatum* L.) in reducing damage from root-knot nematodes to subsequent crops (14,15). The objective of this work was to develop relationships between initial (Pi) and final (Pf) population densities of *Meloidogyne* spp. on winter rye crops in field sites and microplots over 3 seasons. Since *Paratrichodorus minor* (Colbran) Siddiqi was common in several of the study sites, data on this nematode are included as well.

MATERIALS AND METHODS

The study involved a variety of microplots and small field plots, in which rye was planted in October or November and harvested in February or March. Due to previous cropping practices and rotations, a range of nematode population densities existed in these plots. Field plots were located at two different sites and microplots at one site.

The field site near Live Oak was located at the Suwannee Valley Agricultural Research and Education Center in Suwannee County, FL, U.S.A. Soil consisted of 87% sand, 5% silt, and 8% clay, with 3% organic matter and a pH of 5.8. A mixture of *Meloidogyne* spp., primarily *M. arenaria* race 1 with some *M. incognita* race 1, and *P. minor* were present at this site. 'Vita Graze' rye was planted during the winters of 1991-92 and 1992-93 in rows 15 cm apart. Individual plots were 9.2 m long × 4.6 m wide. Summer crops and other cultural practices for this site are described elsewhere (13).

The field site at the University of Florida agronomy farm in Alachua County was planted with 'Wrens Abruzzi' rye during the winter of 1993-94. *Meloidogyne incognita* race 1 occurred at this site, and soil consisted of 91% sand, 4.5% silt, and 4.5% clay, with 1.8% organic matter and pH 5.7. Plot dimensions and row spacings were identical to those used at Live Oak, and the site history is described in detail elsewhere (1).

Microplots were located at the University of Florida agronomy farm and consisted of 60-cm wide fiberglass sheets inserted 50-cm-deep into the soil to give a 76-cm-diam microplot. Microplots were arranged in rows 1.5 m apart in a soil with 93% sand, 4% silt, and 3% clay, with 1% organic matter and pH 5.8. As a result of previous cropping practices and experiments (11,12), a range of population densities of *M. arenaria* race 1 and *P. minor* occurred in the microplots. 'Wrens Abruzzi' rye was broadcast in the microplots during the winters of 1990-91, 1991-92, and 1992-93.

All plots were sampled at the beginning and end of each rye crop (Table 1) to estimate Pi and Pf. Five soil cores (2.5-cm-diam to a 20-cm depth) per microplot, or 6 cores per field plot, were collected and mixed to form a sample. Nematodes were extracted from a 100-cm^3 subsample by the centrifugal-flotation method (5).

Data for *Meloidogyne* spp. and *P. minor* were analyzed separately. Data sets from 3 sites over 1 to 3 seasons were available for *Meloidogyne* spp. and from 2 sites over 2 seasons for *P. minor* (Table 1). Only plots with nonzero Pi were included in these data sets. For each data set, correlations between log-transformed (base e) Pf and Pi were calculated (3), but in order to derive relationships between Pf and Pi, data were first grouped into population density classes (2). Data were sorted in order of increasing Pi and grouped into 9-10 density classes. The numbers of plots in each density class were similar within a data set (Table 1) but were not always equal because the total number of non-zero plots available was not always divisible evenly. Pf and Pi means within each density class were used to determine the regression of $\log_e$ (Pf+1) on $\log_e$ (Pi+1) for each data set. Regression lines for different data sets were compared using a test for equality of slopes (3).

RESULTS

The logarithms of Pi and Pf of *Meloidogyne* spp. were correlated ($P \leq 0.01$) in every location and season (Table 2). It was difficult to determine relationships between Pf and Pi across seasons and locations, due to the large number of individual plots ($\Sigma n = 317$). However, the means of the population density classes revealed similar relationships between Pf and Pi across the 6 data sets (Fig. 1). Most data points were near or slightly below the

maintenance line, where $\log_e$ (Pf+1) = $\log_e$ (Pi+1). In each instance, a linear relationship ($P \leq 0.01$) between $\log_e$ (Pf+1) and $\log_e$ (Pi+1) was evident (Table 3). The slopes of 5 of these regression equations were not different, but the slope for the equation based on field plots at the agronomy farm differed ($P \leq 0.05$) from those of all other equations, except that from field plots at Live Oak in 1992-93. The field plots at the agronomy farm contained *M. incognita* race 1, whereas *M. arenaria* race 1 predominated at the other locations. Pooled data from the 5 similar data sets (Fig. 2) produced the common regression equation, $\log_e$ (Pf+1) = 0.863 $\log_e$ (Pi+1) - 0.26 ($r^2 = 0.863$; $P \leq 0.01$; $n = 48$).

Correlations between log-transformed Pf and Pi were less evident for *P. minor* than for *Meloidogyne* spp. (Table 2). However, linear relationships between untransformed Pf and Pi were apparent with *P. minor* (Fig. 3, Table 3). The slope of the regression line relating Pf and Pi of *P. minor* in microplots during the 1991-92 season differed ($P \leq 0.05$) from that for the 1992-93 season. A similar result occurred in field plots at Live Oak, where the slopes of regression equations (Table 3) for the 1991-92 season and the 1992-93 season also differed ($P \leq 0.05$). Since slopes of regression equations were different, no attempt was made to fit a common equation to pooled data for *P. minor*.

DISCUSSION

For sites dominated by *M. arenaria* race 1, the consistency of regression equations and slopes across sites and seasons suggests that the common regression model (Fig. 2) developed across seasons and locations may be useful for predictive purposes. The slope of a corresponding regression equation from a site dominated by *M. incognita* race 1 was less than the slopes

Table 1. Nematodes, sampling dates, number of plots, and density class information for sites with winter rye in north Florida, 1990-1994.

Location	Nematode(s)[x]	Sampling dates[y]		No. plots	Density classes[z]
		Pi	Pf		
Microplots	Meloidogyne arenaria	2 Oct. 1990	13 Mar. 1991	80	10 classes of 8 each
Microplots	Meloidogyne arenaria	29 Oct. 1991	27 Feb. 1992	70	10 classes of 7 each
Microplots	Meloidogyne arenaria	26 Oct. 1992	3 Feb. 1993	68	8 classes of 7 each (2@6)
Field, Live Oak	Meloidogyne spp.	24 Oct. 1991	11 Feb. 1992	27	9 classes of 3 each
Field, Live Oak	Meloidogyne spp.	2 Nov. 1992	12 Feb. 1993	35	8 classes of 4 each (1@3)
Field, agronomy farm	Meloidogyne incognita	14 Oct. 1993	10 Feb. 1994	37	8 classes of 4 each (1@5)
Microplots	Paratrichodorus minor	29 Oct. 1991	27 Feb. 1992	22	8 classes of 2 each (2@3)
Microplots	Paratrichodorus minor	26 Oct. 1992	3 Feb. 1993	46	8 classes of 5 each (1@6)
Field, Live Oak	Paratrichodorus minor	24 Oct. 1991	11 Feb. 1992	42	8 classes of 4 each (2@5)
Field, Live Oak	Paratrichodorus minor	2 Nov. 1992	12 Feb. 1993	47	7 classes of 5 each (2@6)

[x]Race 1 of M. arenaria and M. incognita. The Live Oak field contained a mixture of M. incognita race 1 and M. arenaria race 1, dominated by the latter species.

[y]Pi = date of initial samples; Pf = date of final samples of rye crop.

[z]Number of classes and number of plots in each class. 2@6 means 2 additional classes had only 6 plots.

Table 2. Correlation coefficients (*r*) between $\log_e$ (Pf+1) and $\log_e$ (Pi+1) for *Meloidogyne* spp. and *Paratrichodorus minor* at several location with winter rye.

Location	Season	*Meloidogyne* spp.		*Paratrichodorus minor*	
		n	*r*	*n*	*r*
Microplots	1990-91	80	0.686**	–	–
Microplots	1991-92	70	0.836**	22	0.446*
Microplots	1992-93	68	0.715**	46	0.381**
Field, Live Oak	1991-92	27	0.684**	42	0.514**
Field, Live Oak	1992-93	35	0.603**	47	0.026
Field, agronomy farm	1993-94	37	0.682**	–	–

**r significant at $P \le 0.01$; *r significant at $P \le 0.05$.

from sites where *M. arenaria* predominated, indicating that *M. incognita* population densities increase more slowly (or decline more quickly) on rye.

The regression model relating $\log_e$ (Pf+1) to $\log_e$ (Pi+1) for *M. arenaria* (Fig. 2) lies slightly beneath the maintenance line where $\log_e$ (Pf+1) = $\log_e$ (Pi+1), and the slope (= 0.863) is slightly less than 1.0. This implies that a slight decline in *M.*

arenaria population density is expected across the range of Pi. Thus as a cover crop or rotation crop, rye may be preferable to some legumes such as crimson clover, white clover (*Trifolium repens* L.), or alyce-clover (*Alysicarpus* spp.) which are highly susceptible and may increase population densities of *M. arenaria* and other *Meloidogyne* spp. (14,19,21). However, while rye is somewhat suppressive to *M. arenaria*, these

Table 3. Relationship between initial (Pi) and final (Pf) population densities of *Meloidogyne* spp. and *Paratrichodorus minor* on winter rye.

Location	Season	r^2	Regression equation
Meloidogyne spp.			
Microplots	1990-91	0.916**	$\log_e(Pf+1) = 1.02 \log_e(Pi+1) - 1.57$
Microplots	1991-92	0.956**	$\log_e(Pf+1) = 0.911 \log_e(Pi+1) - 0.09$
Microplots	1992-93	0.914**	$\log_e(Pf+1) = 0.843 \log_e(Pi+1) + 0.53$
Field, Live Oak	1991-92	0.787**	$\log_e(Pf+1) = 0.933 \log_e(Pi+1) - 1.22$
Field, Live Oak	1992-93	0.884**	$\log_e(Pf+1) = 0.751 \log_e(Pi+1) - 0.54$
Field, agronomy farm	1993-94	0.857**	$\log_e(Pf+1) = 0.536 \log_e(Pi+1) + 0.19$
Paratrichodorus minor			
Microplots	1991-92	0.518*	Pf = 0.765 Pi + 22.0
Microplots	1992-93	0.943**	Pf = 3.14 Pi + 3.60
Field, Live Oak	1991-92	0.750**	Pf = 0.942 Pi + 90.2
Field, Live Oak	1992-93	0.686**	Pf = 0.172 Pi + 38.8

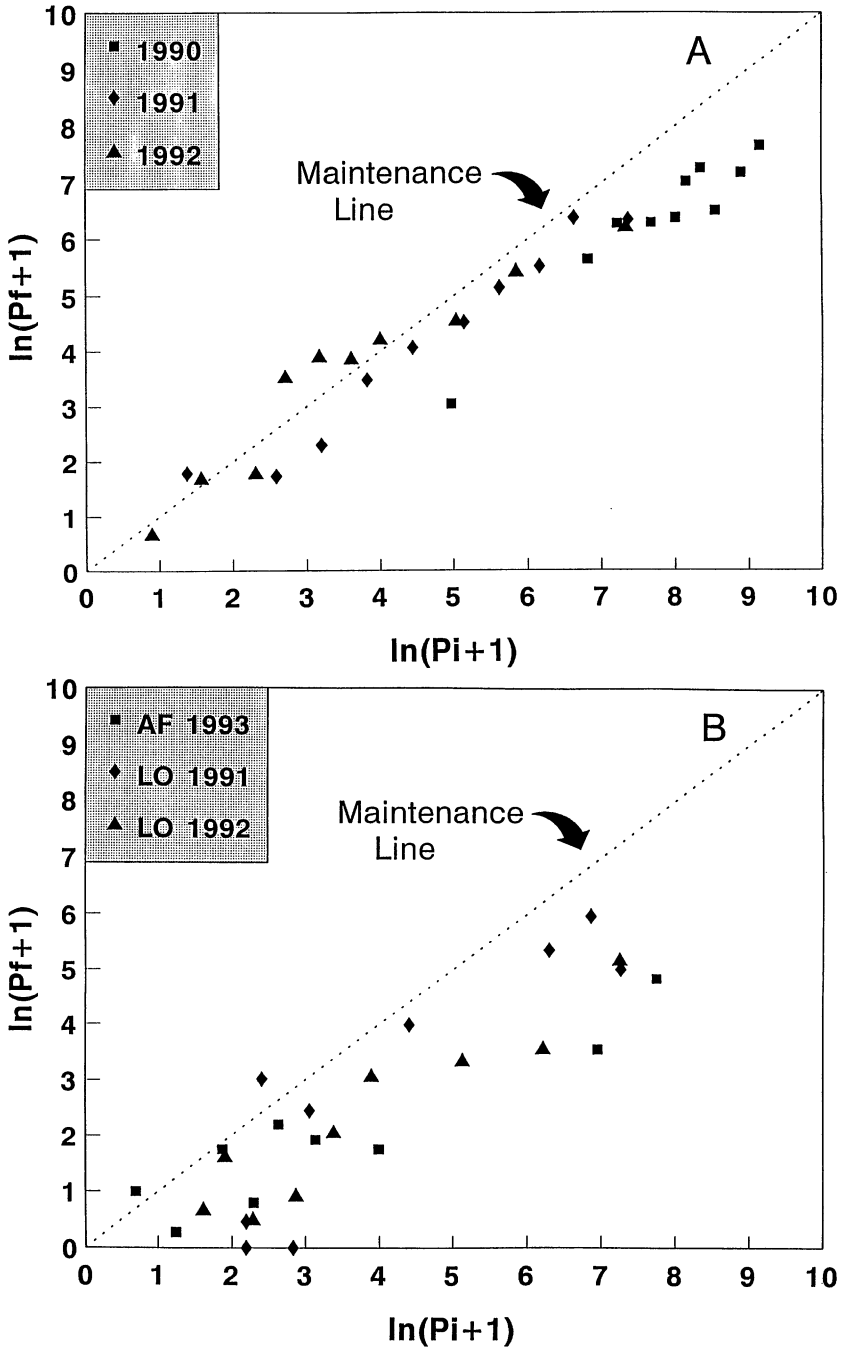**r^2 significant at $P \le 0.01$; *r^2 significant at $P \le 0.05$.

Fig. 1. Logarithms of initial (Pi) and final (Pf) densities of *Meloidogyne* spp. per 100 cm³ soil for density class data from three locations with winter rye. Year in legend refers to year in which rye crop was planted, e.g., 1990 refers to 1990-91 season. A. Microplots. B. Field plots at agronomy farm (AF) and Live Oak (LO).
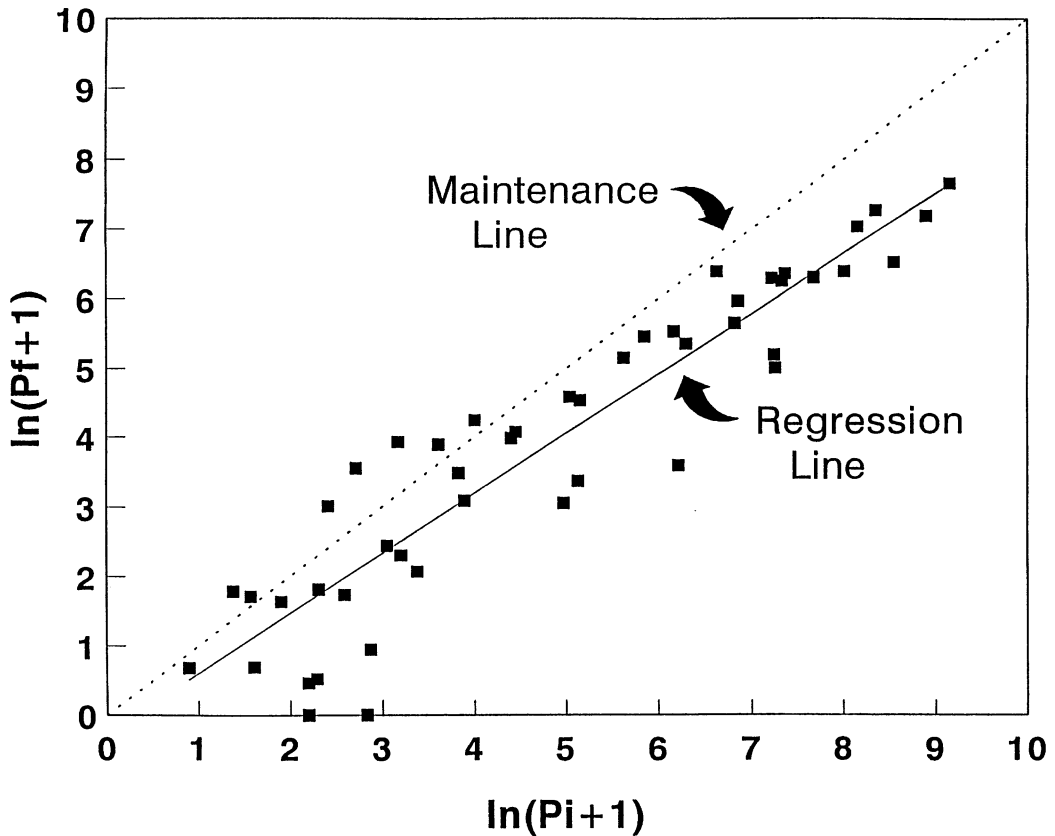
Fig. 2. Relationship between log-transformed initial (Pi) and final (Pf) densities of *Meloidogyne* spp. on winter rye, for density class data from microplots over three seasons and field plots at Live Oak, Florida, over two seasons. Equation for regression line: $\log_e(Pf+1) = 0.863 \log_e(Pf+1) - 0.26$ ($r^2 = 0.863$; $P \leq 0.01$; $n = 48$).

data indicate that rye is not particularly effective in greatly decreasing *M. arenaria* population densities, but will nearly maintain existing densities in many cases. It is probably fortunate that rye is used as a cover crop in the southeastern United States in the winter, when low temperatures may limit nematode reproduction (7). It is possible that increases in *Meloidogyne* spp. population densities could occur if rye is grown in other seasons or in warmer climates, but additional research is needed to test this hypothesis. Additional work is needed as well to find useful cover crops

and rotation crops which will suppress, rather than maintain, existing densities of *Meloidogyne* spp. and other damaging nematodes.

Observed ranges in Pi and Pf were less for *P. minor* than for *Meloidogyne* spp. The models developed here are inadequate for predicting population dynamics of *P. minor* on rye because relationships between Pf and Pi varied with site and season. Additional seasons of data are needed to better define the dynamics of this nematode. With additional data sets, it may be possible to determine probability values for fre-
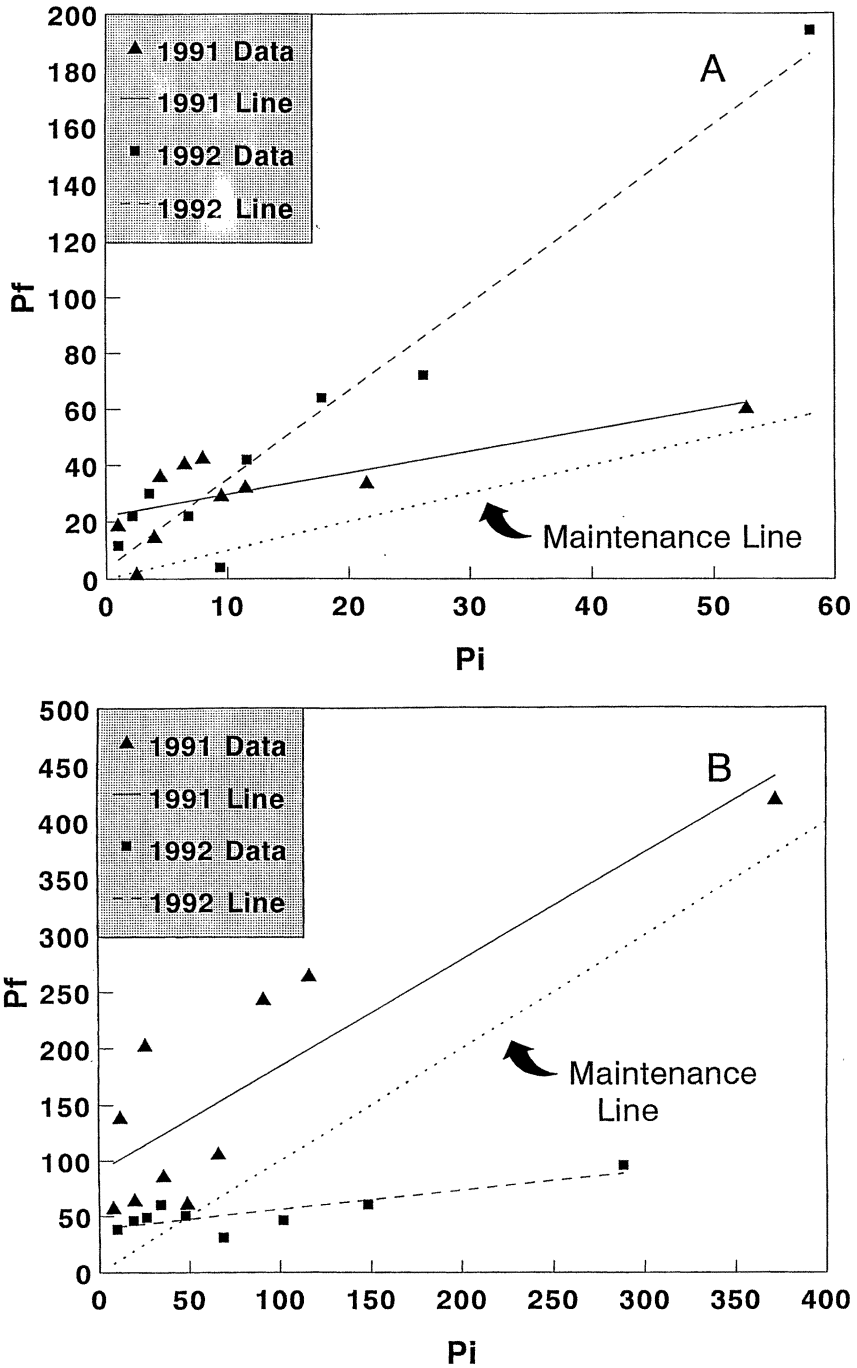
Fig. 3. Relationship between initial (Pi) and final (Pf) densities of *Paratrichodorus minor* on winter rye, for density class data over two seasons, 1991-1992. A. Microplots. B. Field plots at Live Oak, Florida. See Table 3 for equations of regression lines.

quency of occurrence of the various alternative equations to introduce an element of seasonal variation into forecasts of nematode population densities (9).

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