CORRELATION BETWEEN *PARATRICHODORUS MINOR* POPULATION LEVELS AND CORKY RINGSPOT SYMPTOMS ON POTATO†

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RESUMEN

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Dos cultivos de papa fueron establecidos entre los años 1993 y 1995. Diesiséis parcelas de papa variedad Red LaSoda fueron arregladas en un diseño de bloques al azar. Todos los tubérculos de cada parcela fueron cosechados, enumerados, y examinados para determinar incidencia y severidad de la mancha de anillo corchoso (MAC). Muestras de suelo para extracción de nematodos fueron colectadas durante el período de crecimiento de la papa. La cantidad de *P. minor* en cada fecha de muestreo estuvo asociada con incidencia y severidad de MAC en los tubérculos dos meses después de plantación en las dos cosechas ($P \leq 0.05$).

Palabras claves: Función de daño, mancha de anillo corchoso, *Paratrichodorus minor*, papa.

Paratrichodorus minor (Colbran) Siddiqi transmits the tobacco rattle virus (TRV) (Walkinshaw *et al.*, 1961) to potato (*Solanum tuberosum* L.), causing the disease known as corky ringspot (CRS). External symptoms, when present, are characterized by circular lesions on the epidermis of affected tubers and internal symptoms show as necrotic arcs or rings in tubers (Weingartner *et al.*, 1983). Corky ringspot on potatoes may result in economic losses of up to 25% (Weingartner and Shumaker, 1990a; Weingartner and Shumaker, 1990b).

A defined relationship between crop yield and population densities of plant-parasitic nematodes may aid in management decisions (Seinhorst, 1965). Nematode population densities at planting or at other times during the growing season can be negatively correlated with crop yield (Barker and Nusbaum, 1971; Mashela *et al.*, 1991).

Since *P. minor* transmits the causal agent of CRS, it may be possible to correlate *P. minor* numbers with incidence or severity of CRS on potato tubers (Cooke, 1973). The objective of this experiment was to correlate *P. minor* population densities at different times during the potato growing season with incidence (proportion of infected tubers) or severity (extent of symptoms in individual tubers) of CRS on potato tubers at harvest.

Experiments were conducted during two winter growing seasons from 1993 to 1995 at the University of Florida, Institute of Food and Agricultural Sciences, Research and Education Center, Yelvington Farm near Hastings, Florida. Soil texture of the experimental field was 95% sand, 2% silt, 3% clay, and 1.4% organic matter; pH 5.5-6.0. The field was naturally infested with *P. minor* and had a long history of CRS on potato. The potato var. Red

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LaSoda was planted on 21 December 1993 for the 1993-94 season and 23 January 1995 for the 1994-95 season. Sixteen single-row, 10-m long plots were arranged in a completely randomized design. A plot was either not treated or treated with 56 L/ha of the soil fumigant 1,3-dichloropropene applied 32-cm deep in row with a single chisel on 24 November 1993 and 16 December 1994. Standard practices for fertilizer application, and for insect, weed, and disease management were used (Hochmuth *et al.*, 1996). The crop was irrigated as needed (Rogers, *et al.*, 1975).

All potato tubers from each plot were harvested mechanically on 7 June 1994 and 25 May 1995. Harvested tubers were washed, graded, and all the tubers from each plot (>3.0 cm diam.) were counted. Potato tubers were examined for external and internal symptoms of CRS and the proportion of infected tubers (incidence) was determined. External and internal incidence and severity of CRS was determined for each plot. Severity index values from 0 to 10 were assigned to all potatoes from each plot. Severity was assessed by cutting the tuber into eight pieces and examining each piece for internal and external symptoms. Severity values from 0 to 8 equaled the number of potato pieces with symptoms, 9 = all pieces showing symptoms with each piece having 25% to 50% of the surface affected, and 10 = all pieces showing symptoms with each piece having >50% of the surface affected. Mean severity for a plot was calculated by adding the severity index values of each affected tuber and dividing by the total number of tubers for that plot.

Soil samples for nematode assays were taken 0-20 cm and 20-40 cm deep. Samples consisted of six cores (2.5 cm diam.) taken from each plot at various dates during the 1993-94 and 1994-95 potato growing seasons. The six cores were mixed and a 100-cm^3 subsample was used for nematode extraction by a centrifugal-flotation technique (Jenkins, 1964). The extracted nematodes were identified and counted.

Since numbers of *P. minor* are known to fluctuate between soil depths of 0-20 cm and 20-40 cm (McSorley and Dickson, 1990), nematode counts from the two depths were added together and transformed ($y = ln(x + 1)$, where x = number of *P. minor*/100 cm^3 of soil). Simple linear correlation coefficients were calculated between log-transformed numbers on each sampling date and incidence (external and internal) or mean severity (internal and external) using SAS (SAS Institute, Cary, NC).

A positive correlation ($P \leq 0.05$) between *P. minor* numbers and external or internal incidence or severity of CRS (Tables 1 and 2) was observed. For a given date in a year, the correlation coefficients were similar for all the different types of symptoms. A previous study showed that both external or internal incidence and severity were highly associated in the potato variety Red LaSoda ($r \geq 0.92$) within a year (Pérez, 1997).

The significant correlations ($P \leq 0.05$) between early nematode counts and incidence or severity of CRS in the 1993-94 season (Table 1) suggests that the virus can be transmitted by *P. minor* during the first month of the potato growing season. Early-season correlations were not observed in 1994-95, however (Table 2).

One month after planting, the precipitation was higher in the 1993-94 (17.3 cm) than in the 1994-95 season (4.2 cm). There is evidence that rainfall affected trichodorid densities and CRS incidence in other studies. In England, a significant association between the prevalence of sugar beet (*Beta vulgaris* L.) docking disorder in June, caused by trichodorid-transmitted TRV, and rainfall in May was

Table 1. Simple linear correlation coefficients between external incidence, internal incidence, mean external severity, or mean internal severity of corky ringspot tuber symptoms and *Paratrichodorus minor* numbers (after log transformation) at different sampling dates, 1993-94 season.

Corky ringspot symptoms	23 Nov.	21 Dec.	21 Jan. 30 DAP[x]	25 Feb. 64 DAP	21 Mar. 89 DAP	4 April 103 DAP	18 April 117 DAP
External incidence[y]	0.18	0.37	0.56*	0.60**	0.20	0.66**	0.43*
Internal incidence	0.34	0.54*	0.67**	0.59*	0.26	0.57*	0.50**
Mean external severity[z]	0.39	0.47	0.61**	0.50*	0.32	0.69**	0.61**
Mean internal severity	0.50*	0.59**	0.69**	0.56*	0.33	0.62**	0.60**

*Significant ($P \leq 0.05$), **significant ($P \leq 0.01$).
[x]Days after planting.
[y]Incidence = proportion of symptomatic tubers.
[z]Severity = extent of symptoms in tubers (see text for severity rating scale).

Table 2. Simple linear correlation coefficients between external incidence, internal incidence, mean external severity, or mean internal severity of corky ringspot tuber symptoms and *Paratrichodorus minor* numbers (after log transformation) at different sampling dates, 1994-95 season.

Corky ringspot symptoms	22 Nov.	23 Dec.	27 Feb. 34 DAP[x]	27 Mar. 62 DAP	5 May 100 DAP
External incidence[y]	0.18	0.01	0.10	0.79**	0.24
Internal incidence	0.23	0.27	0.28	0.77**	0.07
Mean external severity[z]	0.28	0.12	0.20	0.80**	0.23
Mean internal severity	0.30	0.17	0.33	0.82**	0.19

*Significant ($P < 0.05$), **significant ($P < 0.01$).
[x]Days after planting.
[y]Incidence = proportion of symptomatic tubers.
[z]Severity = extent of symptoms in tubers (see text for severity rating scale).

observed (Cooke, 1973). In Scotland, trichodorid densities in May, when rains were high, were more associated with CRS incidence than trichodorid densities at harvest (Cooper and Thomas, 1971). Highest incidence of CRS coincided with the wettest summers during the period 1933-39 in Scotland (Cooper and Harrison, 1973). Van Hoof (1976) showed that infection of tobacco by trichodorids carrying TRV increased with increasing soil moisture due to enhanced movement of nematodes in wet soils. Infection of potato tubers with TRV takes place only when trichodorids feed on developing tubers (Van Hoof 1964). In the current study, precipitation was high in 1993-94 season during the first month after planting when tubers were forming. High soil moisture might have caused increased nematode activity when potato tubers were forming and were susceptible to infection by TRV. This could explain the higher incidence of CRS during the 1993-94 season (Table 3).

Data in these experiments suggested that most of the transmission of TRV took place during the first 2 months after planting and continued throughout the potato

Table 3. Mean[x] external and internal incidence and severity of corky ringspot tuber symptoms and *Paratrichodorus minor*/100 cm^3 of soil at planting (Pi) from all 16 plots, 1993-94 and 1994-95 seasons.

Season	Pi	External incidence[y]	Internal incidence	External severity[z]	Internal severity
1993-94	23	0.49	0.44	1.92	2.09
1994-95	16	0.19	0.20	0.51	0.80

[x]Mean from all potato tubers from 16 plots, including noninfested potato tubers.
[y]Incidence = proportion of symptomatic tubers.
[z]Potato tubers were cut into eight pieces, severity values from 0 to 8 equaled the number of potato pieces with symptoms, 9 = all pieces showing symptoms with 25% to 50% of the surface affected; 10 = all pieces with symptoms >50% of the surface necrotic.

growing season. Significant associations between *P. minor* densities and incidence or severity of CRS were obtained two months after planting in both years. This suggests that early *P. minor* densities may be the most reliable predictors of incidence or severity of CRS at harvest.

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