RESEARCH NOTE/NOTA DE INVESTIGACIÓN

MANAGEMENT OF *PRATYLENCHUS COFFEAE* ON BANANA PLANTLETS BY SOLARIZATION

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ABSTRACT

Araújo, J. J. S., M. F. S. Muniz, S. S. Lima, G. Moura Filho, J. L. Souza, and R. A. Ferreira Junior. 2018. Management of *Pratylenchus coffeae* on banana plantlets by solarization. Nematropica 48:21-26

The objective of this work was to investigate the effects of solarization on banana rhizome seedlings infected with *Pratylenchus coffeae*. The experiment was performed outdoors, during the dry season, with infected rhizomes wrapped within two layers of clear plastic bags and exposed to sunlight for 0, 2, 6, and 8 h, from 08:30 to 16:30 hr. The air temperatures of the area were recorded, and the rhizome temperatures were recorded and registered automatically and continuously with a PROB-107 sensor. After exposure to sunlight, the infected rhizomes were grown in pots containing sterilized soil under greenhouse conditions for 3 months. The percentage of sucker emergence and nematode population in the root, rhizome, and soil was recorded. Solarization treatments did not affect sucker emergence. The maximum temperatures registered in the rhizomes were of 27.0, 36.9, 54.3 and 51.8ºC (corresponding to the exposure periods of 0, 2, 6, and 8 hr, respectively). The sunlight exposition treatment of infected rhizomes for 6 and 8 hr reduced the population density of *P. coffeae*. Solarization is a promising method to reduce plant-parasitic nematode populations in banana plantlets.

Key words: heat treatment, lesion nematode, *Musa* spp.

RESUMO

Araújo, J. J. S., M. F. S. Muniz, S. S. Lima, G. Moura Filho, J. L. Souza, e R. A. Ferreira Junior. 2018. Manejo de *Pratylenchus coffeae* em mudas de bananeira por meio da solarização. Nematropica 48:21-26.

O objetivo deste trabalho foi avaliar o tratamento de mudas infectadas com *Pratylenchus coffeae* com o uso da solarização. O experimento foi implantado no Centro de Ciências Agrárias - CECA, em área a céu aberto, em dia quente e seco. As mudas infectadas foram envoltas em sacos plásticos transparentes durante 0, 2, 6 e 8 hr, no período de 8:30 às 16:30 hr. A temperatura do ar do local foi registrada assim como foram obtidas medições automáticas e contínuas da temperatura dos rizomas com o sensor PROB-107. Posteriormente, as mudas foram cultivadas em vasos contendo solo esterilizado e mantidas em casa de vegetação. A avaliação do experimento foi realizada três meses após a aplicação dos tratamentos, observando-se o percentual de brotação das mudas e a população de nematoides em raiz, rizoma e solo. Ao final do período experimental obteve-se 100% de brotação das mudas em todos os tratamentos. A temperatura máxima alcançada nos rizomas em cada tratamento foi de 27, 36,9, 54,3 e 51,8ºC, correspondendo aos tempos de exposição de 0, 2, 6 e 8 hr, respectivamente. Os resultados obtidos mostraram que os períodos de 6 e 8 horas de exposição das mudas à energia solar proporcionaram as maiores reduções da densidade populacional de *P. coffeae*.

Palavras chave: *Musa* spp., nematoide das lesões radiculares, termoterapia

Banana (*Musa* spp.) is the second most cultivated fruit crop in Brazil, with an annual production of approximately 7 million tons. In Brazil, the major banana-growing areas are located in the Northeast region, with approximately 33% of the overall national production (IBGE, 2015). Yet, average Brazilian productivity at 14.5 t/ha remains low compared to global leaders such as India at 37.0 t/ha per year (FAO, 2014). Plant-parasitic nematodes may cause severe losses to banana production (Sarah, 1989; Gowen *et al*., 2005). In cash crops, production losses ranging from 10% to 50% have been documented (Pinochet, 1986; Davide, 1996). In Brazil, losses reaching 100% have been recorded (Zem, 1982).

More than 140 species of plant-parasitic nematodes are associated with *Musa* spp. (Gowen *et al*. 2005). Among the most important plant-

parasitic nematodes infecting *Musa* spp. are *Radopholus similis* (Cobb, 1893) Thorne, *Pratylenchus coffeae* (Zimmerman) Filipjev & Schuurmans Stekhoven, *Helicotylenchus multicinctus* (Cobb) Golden, *H. dihystera* (Cobb) Sher, *Meloidogyne* spp. Goeldi, and *Rotylenchulus reniformis* Linford & Oliveira.

Some of the major nematode management techniques for banana production in Brazil are tissue-cultured propagated plants, crop rotation with *Crotalaria* spp. or *Tagetes* spp., and the use of organophosphate and carbamate nematicides (Salomão and Siqueira, 2015; Cordeiro *et al*., 2016). Another useful technique previously tested in other countries consists in the solarization of banana planting material (Mbwana and Seshu-Reddy, 1995; Gaidashova *et al*., 2003; Wang and Hooks, 2009). Only limited information on solarization against plant-parasitic nematodes on banana is available in Brazil. Therefore, this research, aimed to evaluate solarization of the banana propagative material, is needed.

The experiment was established in an open area on December 22, 2014, during the dry season near the Agrometeorological Station, Center for Agricultural Sciences, Federal University of Alagoas (09°28'02" S, 35°49'43" W and 127 m altitude). Air temperature data were obtained from this automatic meteorological station. Continuous and automatic measurements of the temperature in banana rhizomes were collected at 10-sec intervals using a PROB-107 sensor (Campbell Scientific Inc., Logan, UT, USA), which was buried into a 10-cm hole bored into in the banana rhizome throughout the central cylinder (Fig. 1). The average temperature was stored every 10 min with the aid of a CR1000 data logger (Campbell Scientific, Logan, UT, USA).

Planting material consisted of suckers of banana cv. Comprida (cooking banana) obtained from a field with a history of infection by *P. coffeae*. All the roots were removed according to the local farmers' practice. Before the application of the treatment, the initial population (Pi) of nematodes was estimated in 10 g of rhizome using a maceration-centrifugal flotation method (Coolen and D'Herde, 1972).

The experiment was designed in a completely randomized layout with four treatments and five replications. The treatments consisted of four increasing hours of solarization periods: 0, 2, 6, and 8 h, within the period of 8:30 to 16:30 h, with rhizomes being individually wrapped in a double layer of transparent 14-µm thick plastic film. One-day periods were used based on a preliminary assay. After the application of each treatment, the plantlets were transferred to 8-L plastic pots filled with sterilized soil and maintained under greenhouse conditions for 3 months.

Fig. 1. PROB-107 sensor used to measure the internal temperature of banana rhizomes by embedding the temperature probe in rhizome tissue.

The percentage of sucker emergence and the nematode population in the soil, rhizome, and roots were evaluated after the 3-month period. Nematodes were extracted from 100 cm³ of soil and 10 g of roots and 10 g of rhizome using centrifugation-flotation methods (Coolen and D'Herde, 1972; Jenkins, 1964).

Following extraction, nematodes were fixed in a 4% formaldehyde heated solution. The nematode population was estimated based on the counting of 1 ml suspension in a Peters' slide, under an inverted light microscope. The fixed *Pratylenchus* was identified to species (Gonzaga *et al*., 2012). Nematode reproduction factor (Rf) [Rf = final population (root+rhizome+soil)/initial population from the rhizome] for each sample was calculated according to Oostenbrink (1966).

The Lilliefors-test of homogeneity of variances and normality was applied and a square root transformation ($\sqrt{x+1}$) used to normalize the data. Data were subjected to analysis of variance using the F-test, and means were compared by the Scott-Knott test at 5% probability. In addition, regression analyses between the number of nematodes in the rhizome, roots, and soil, final nematode population, and Rf versus the period of exposition to the sunlight were performed. All statistical analyses were conducted using the software SAEG 5.0 (UFV, Viçosa, MG, Brazil). Heat units (in degree hours) were calculated according to Wang and McSorley (2008): Heat units = $(T_m - T_b)$ x hours of exposure, where T_m = the measured experimental temperature and T_b = an experimentally determined base or threshold temperature for heat unit accumulation, considering 38ºC as base temperature.

The initial evaluation of populations of nematode in banana rhizomes showed the presence of only *P. coffeae*, with averages that ranged from 1,264 to 1,952 nematodes/10 g of tissue (Table 1). No difference in Pi was observed (P>0.05) among treatments, demonstrating uniformity of infection level within the banana suckers tested. At the end of the experiment, 100% of the planting material developed normally, regardless of the treatment, even though control plants were visually taller than solarized plants. Reduction of nematode population densities and Rf was observed after the solarization period of 6 h, despite the large nematode population recovered (1,280-3,320 nematodes/10 g roots) due to the use of heavily infected banana suckers (Table 1). According to

Table 1. Population of *Pratylenchus coffeae* in banana plantlets exposed to different lengths of solarization. Initial and final nematode population is in 10 g of rhizome or roots and in 100 cm^3 soil. The final nematode population and reproduction factor (Rf) are calculated 3 months after solarization of the planting material.

Exposure period (hours)	Initial population	Final population			Total number of nematodes[y]	Reproduction Factor (Rf)
		Rhizome	Roots	Soil		
0	1,246 a[z]	2,280 a	26,080 a	8,000 a	36,360 a	42.31 a
2	1,952 a	6,760 a	25,640 a	14,550 a	46,950 a	29.17 a
6	1,784 a	180 b	3,320 b	3,200 b	6,700 b	7.49 b
8	1,445 a	160 b	1,280 b	1,820 b	3,260 b	2.51 b
MSR	81.6333[ns]	3,803.42*	23,818.27**	7,925.083**	33,490.22**	22.2793**
CV (%)	43.9	100.7	48.6	55.2	37.9	46.73

[y] Rhizome+Roots+Soil.
[z] Averages of five replications. Data followed by the same letter within a column do not differ at 5% probability level by the Scott-Knott test. Analysis of variance with the data converted into $\sqrt{x+1}$. MSR (mean-square residue). **, *Significant at 1 and 5% probability by F-test, respectively. [ns]not significant at a probability higher than 5% by the F-test. C.V. = Coefficient of variation.

Fernández and Ortega (1998), economic threshold densities of *P. coffeae* have been estimated at 5,000-10,000 nematodes/100 g roots in high-fertility soils, whereas 1,000-5,000 nematodes/100 g roots constitute a threshold in low-fertility soils.

Solarization promoted an increase in the temperature of the rhizomes, up to 54.40°C, registered at 14:40 h, while the maximum air temperature was 31.5ºC, at 13:00 h (Fig. 2). According to Ferraz and Brown (2002), phytonematodes do not survive temperatures higher than about 50°C. Considering heat units, the higher suppression of nematode population required 112.85 accumulated h, equivalent to 7.60 h of exposure to sunlight (Fig. 3).

The regression analyses performed using a cubic inverse model for the nematode population in the rhizome and root; with a quadratic inverse model for soil and final population (Fig. 4), and with a linear model for Rf (Fig. 5) were significant. A slight increase in the nematode population was observed after a 2-h exposure (Fig. 4). The highest temperature reached in the rhizomes was 36.9°C, while the air temperature reached only 29.1ºC (Fig. 2). This result is also in accordance with the heat units, which were near zero (Fig. 3). *Pratylenchus coffeae* is capable of surviving in a wide temperature range, even though the optimum temperature for its development is considered to be 25-30°C (Acosta and Malek, 1979; Tuyet *et al*., 2013).

The few scientific studies published about the use of solarization on banana seedlings infected by plant-parasitic nematodes employed a solarized box constructed of wood and glass, which after reaching an internal temperature of 65°C was used to treat the seedlings for at least 20 min, leading to a drop in P. goodeyi population in plant roots 300, 450, and 650 days after planting (Mbwana and Seshu-Reddy, 1995). On the other hand, Wang and Hooks (2009) recommended the use of a transparent plastic film to wrap the seedlings individually, but did not provide a duration required for the treatment.

The present study used a double plastic-film system aiming at higher efficiency with the solarization technique. Other authors observed an increase in soil temperature using the same system (Raymundo *et al*., 1986; Stapleton *et al*., 1999). Our results proved that solarization is a promising method to reduce nematode populations in banana plantlets and can be used as an alternative to hot water treatment (15-25 min at 55ºC) (Gowen *et al*., 2005). Furthermore, the double layer of plastic film is easier for farmers because hot water treatment is limited due to the cost of the equipment required. Additional field tests are necessary to determine the viability of the double layer solarization technique and the feasible utilization of solarized banana plantlets by farmers.

ACKNOWLEDGMENT

The first author thanks the Coo rdenação de Aperfeiçoamento de P essoal de Nível S uperior

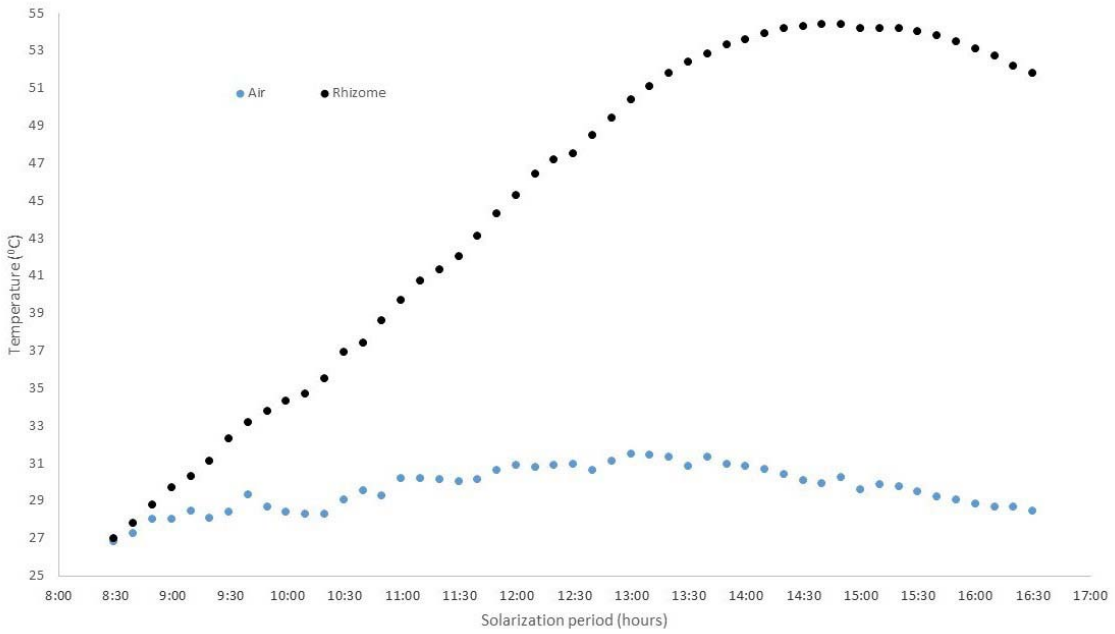

Fig. 2. Temperatures (°C) in banana rhizomes registered with a PROB-107 sensor and in the air as recorded by the Agrometeorological Station during a solarization period.

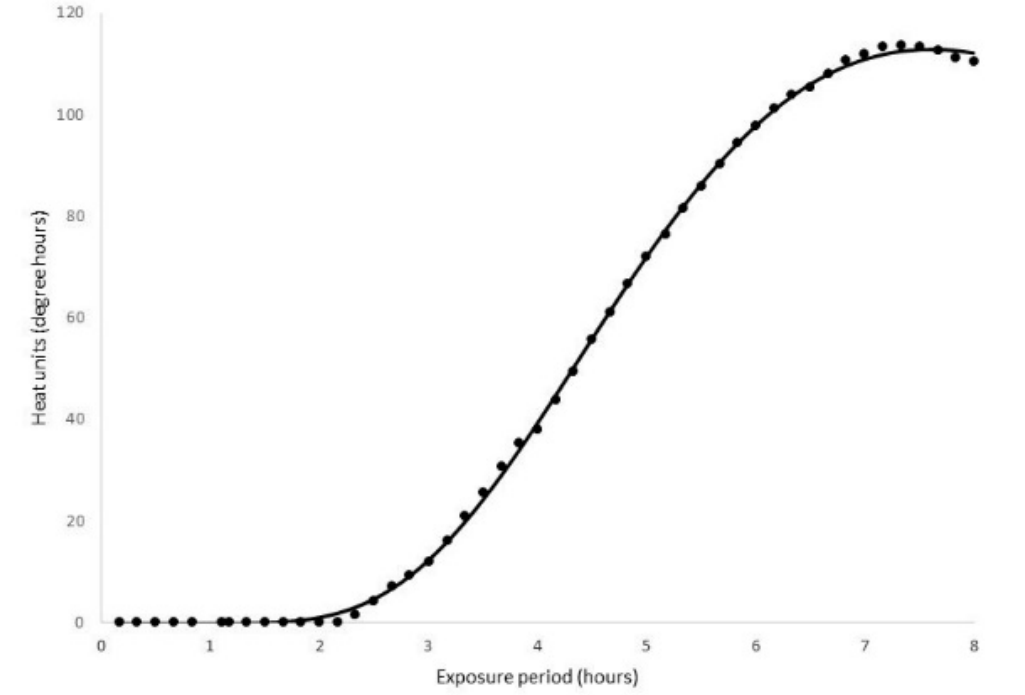

Fig. 3. Heat units observed in banana rhizomes after exposition to solar energy. Log-normal model is: $\hat{Y} = -0.2637 + 113.1103exp^{(-0.5(\ln(x/7.5998)/0.4429)^2)}$ ($R^2 = 0.999; P < 0.01; df = 45$).

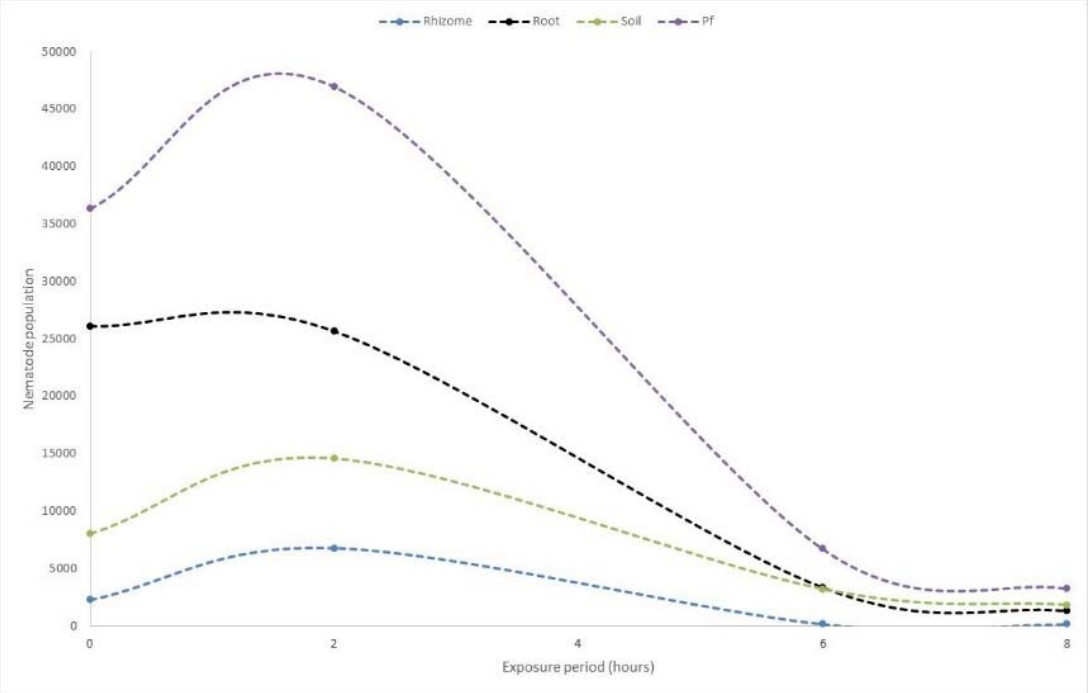

Fig. 4. Predicted *Pratylenchus coffeae* population (y) in banana rhizome, root, and soil and the final nematode population (rhizome+root+soil) in response to different periods of exposure of the banana plantlets to solarization. Equations are: Rhizome $y^{-1} = 0.0228 - 0.0052\ x + 0.000414\ x^3$ ($R^2 = 0.998$, $P < 0.01$, df =1); Root $y^{-1} = 0.0066 - 0.000432\ x + 0.000080\ x^3$ ($R^2 = 0.999$, $P < 0.01$, df =1); Soil $y^{-1} = 0.0114 - 0.0027\ x + 0.00071x^2$ ($R^2 = 0.964$, $P < 0.01$, df =1); Final $y^{-1} = 0.0055 - 0.0012\ x + 0.0004\ x^2$ ($R^2 = 0.999$, $P < 0.01$, df =1).

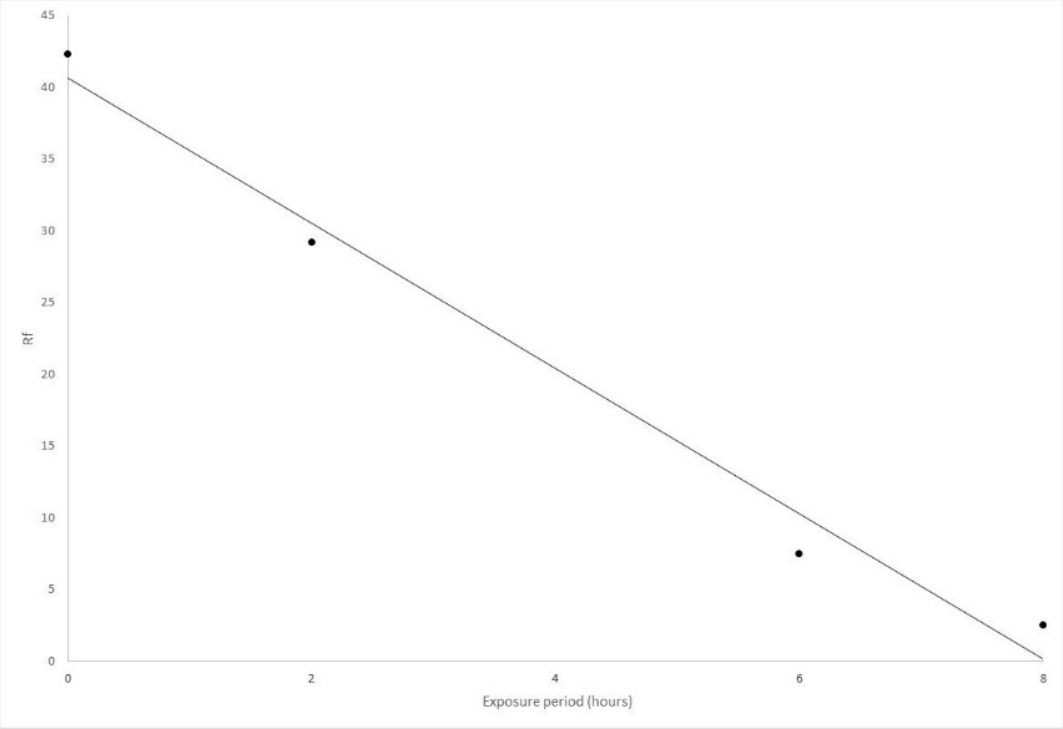

Fig. 5. *Pratylenchus coffeae* reproduction factor (Rf =Pf/Pi) in response to different periods of banana plantlet exposure to solarization. Equation is: $Rf = 6.2060 – 0.5740x$ ($R^2 = 0.986$; $P < 0.01$; df = 2).

(CAPES) for support through a Master's degree scholarship.

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Received: 9/XII/2016 *Accepted for publication:* *17/I/2018*

Recibido: *Aceptado para publicación:*