RESEARCH NOTE – NOTA INVESTIGATIVA

PATHOGENICITY OF *MELOIDOGYNE JAVANICA* ON COMMON BEAN (*PHASEOLUS VULGARIS* L.)

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ABSTRACT

Di Vito, M., B. Parisi, and F. Catalano. 2007. Pathogenicity of *Meloidogyne javanica* on common bean (*Phaseolus vulgaris* L.). Nematropica 37:339-344.

The relationship between a geometric series of 16 initial population densities (*Pi*) of *Meloidogyne javanica* between 0 and 1024 eggs and second stage juveniles (J2)/cm^3 and growth of common bean (*Phaseolus vulgaris*) was investigated in pots in a greenhouse. The Seinhorst model, $y = m + (1 - m)z^{P-T}$, was fitted to plant height, fresh root and top weight. Tolerance limits (*T*) to the nematode for plant height, fresh top weight and root weight of common bean were 1.7, 0.6 and 1.3 eggs and J2/cm^3 soil, respectively. The minimum relative yields were 0, 0 and 0.2 at $P \geq 256$ eggs and J2/cm^3 soil for fresh top weight and root weight and height, respectively. Maximum nematode reproduction rate was 307-fold at the lowest initial population density.

Key words: Javanese root-knot nematode, nematode population dynamics, Seinhorst model, tolerance limit, yield loss.

RESUMEN

Di Vito, M., B. Parisi y F. Catalano. 2007. Patogenicidad de *Meloidogyne javanica* en frijol (*Phaseolus vulgaris* L.). Nematropica 37:339-344.

Se estudió la relación entre una serie geométrica de 16 densidades poblacionales iniciales (*Pi*) de *Meloidogyne javanica*, las cuales oscilaron entre 0 y 1024 huevos y J2/cm^3 de suelo, y el crecimiento de frijol (*Phaseolus vulgaris*) en macetas en invernadero. Los valores de altura, peso fresco aéreo y peso fresco de raíces de las plantas fueron introducidos en el modelo de Seinhorst, $y = m + (1 - m)z^{P-T}$. Los límites de tolerancia al nematodo (*T*) para altura, peso aéreo y peso de raíces fueron 1.7, 0.6 y 1.3 huevos y J2/cm^3 de suelo, respectivamente. Los rendimentos mínimos relativos (*m*) fueron 0.2, 0 y 0 a $P \geq 256$ huevos y juveniles/cm^3 de suelo para altura de las plantas, peso aéreo y peso de raíces, respectivamente. El índice reproductivo máximo del nematodo fue de 307, alcanzado con la menor densidad poblacional inicial.

Palabras claves: dinámica poblacional de nematodos, nematodo agallador, límite de tolerancia, modelo de Seinhorst, pérdida de rendimiento.

Common bean (*Phaseolus vulgaris* L.) is one the most widely cultivated legumes. In 2005, 39,076,770 ha were cultivated worldwide, with a dry seed production of about 22,291,000 MT (FAO, 2007). Several plant parasitic nematodes have been reported to damage the crop (Sikora *et al.*, 2005) with an annual yield loss of about 11% worldwide (Sasser and Freckman, 1987). Among nematode pests, several species of root-knot nematodes (*Meloidogyne* spp.) are pathogens to common bean. *Meloidogyne incognita* (Kofoid and White) Chitwood and *M. javanica* (Treub) Chitwood are the most commonly identified and damaging nematodes of common bean in several countries (Sikora *et al.*, 2005). In Italy, common bean is one of most important food legumes and is often damaged by root-knot nematodes under both greenhouse and field cultivation. Several authors reported yield suppression in common bean induced by root-knot nematodes (McSorley *et al.*, 1981; Crozzoli *et al.* 1997; Di Vito *et al.*, 2005a). They found that the extent of damage to snap bean in greenhouse trials was correlated with the soil population gradient of *M. incognita* at sowing. The tolerance limit of common bean to *M. javanica* was estimated, in greenhouses, to be 1 egg/cm^3 soil in Brazil (Sharma, 1981), while in Venezuela, Crozzoli *et al.* (1997) found that tolerance limits of three common bean cultivars to *M. incognita* were in the range 0.02-0.03 egg/cm^3 soil. In Italy, information on the pathogenicity of *M. javanica* to common bean is lacking. The common bean varieties used by Italian growers are not resistant to root-knot nematodes, and are severely damaged by the Javanese root-knot nematode, *M. javanica*, which is the most common nematode pest in common bean in both field and greenhouse production (Greco *et al.*, 1998). Information on the damaging levels of initial populations of this pest is crucial to implement appropriate management practices, and also needed for comparative purpose in resistance breeding programs.

A study was conducted in clay pots in a greenhouse to determine the effect of initial densities of an Italian population of *M. javanica* on the growth of common bean and on the dynamics of the nematode population on this leguminous crop. The *M. javanica* isolate was collected from peach [*Prunus persica* (L.) Batsch.] at San Ferdinando di Puglia (Foggia, Apulia region, Italy) and reared on tomato (*Lycopersicon esculentum* Mill.) cv. Rutgers in a greenhouse at 26 ± 3°C. When egg masses were formed, tomato roots were gently washed free of adhering soil and finely chopped (1-2 cm long). Nematode population levels in the root mass were estimated in ten 5 g samples removed randomly from the root mass and expressed as eggs and J2/g roots. The root samples were placed in jars containing 100 ml of 1% aqueous solution of sodium hypochlorite and shaken for 4 min to free eggs and J2 from the egg masses (Hussey and Barker, 1973). The entire chopped root mass of 100 g was thoroughly mixed with 3 kg of steam sterilized sandy soil (sand 88%, silt 5%, clay 7% with organic matter 2.5%) and used as a stock nematode inoculum. Chopped infested tomato roots were mixed in the sandy soil medium because this method was found to be more efficient than dispersed eggs (Di Vito *et al.*, 1986). Appropriate amounts of inoculum were then mixed with the soil of each clay pot (600 cm^3 of volume) to provide approximate initial population densities of (*Pi*) 0, 0.0625, 0.125, 0.25, 0.5, 1, 2, 4, 8, 16, 32, 64, 128, 256, 512 or 1024 eggs and J2/cm^3.

A single pre-germinated seed of a root-knot nematode susceptible "Borlotto type" common bean cv Talento was sown in each pot on 11 January 2007. The pots were arranged in a randomized complete block design with six replicates on benches in a greenhouse at 26 ± 3°C. Fifty days after sowing, height and fresh top and root weight of the plants were recorded. The root systems were gently washed, weighed, and gall indices assessed according to a 0-5 scale (Di Vito *et al.*, 1979). Eggs and J2 were extracted from the entire root system as described above, and from all soil in each pot using Coolen's modified method (Coolen, 1979; Di Vito *et al.*, 1985). The sum of the nematodes extracted from roots and soil of the same pot was considered as the final population density (*Pf*) per pot.

The Seinhorst model $y = m + (1 - m)z^{P-T}$ (Seinhorst, 1965, 1979) was fitted separately to data for top and root fresh weights, and plant height. In this model P (= Pi in this study) is the initial population density, y is the ratio between the yield at P and that at $P \leq T$, m is the minimum relative yield (y at very large P), z is a constant <1 with z^{-T} = 1.05, and T is the tolerance limit or threshold (P below which no yield is lost). The reproduction rate of the nematode (Pf/P) is the ratio of the final to the initial population density for each pot. Data for root gall indices were statistically analyzed by ANOVA and the means compared with the Duncan Multiple Range Test.

Environmental conditions in the greenhouse during the experiment were suitable for both common bean plant growth, and nematode infection and reproduction. Plant emergence of common bean was not affected by initial population densities (P) of *M. javanica*, but later growth of the plants was adversely affected. Symptoms of nematode attack (a marked reduction of plant top growth) were evident at the P level of 8 eggs and J2/cm^3 soil.

The tolerance limits (T) of common bean plant height, fresh top weight, and root weight, to *M. javanica* were 1.6, 0.6 and 1.3 eggs and J2/cm^3 soil, respectively (Figs. 1 and 2). The minimum relative yields (m) were 0, 0, and 0.2 at $P \geq 256$ eggs and J2/cm^3 soil for fresh top weight, root weight, and height of plants, respectively.

The largest final population density (Pf) of the nematode was 1180.5 eggs and J2/cm^3 soil, which occurred at P = 128 eggs and J2/cm^3 soil (Table 1). The maximum reproduction rate of the nematode (Pf/P) was 307-fold, and was achieved at the lowest P of 0.125 eggs and J2/cm^3 soil (Table 1). Highest Pf occurred in the pots inoculated with 128 eggs and J2/cm^3 soil (Table 1). The root gall index was lowest (0.8) at lowest P and highest (5.0) at $P \geq 128$ eggs and J2/cm^3 soil (Table 1).

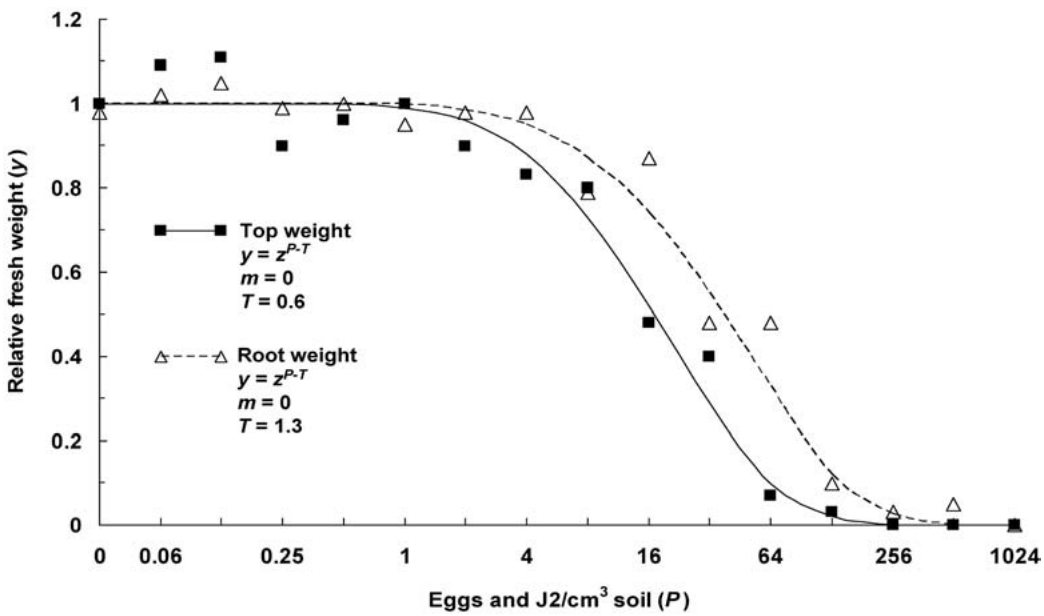

Fig. 1. Relationship between initial population densities (P) of the Italian population of *Meloidogyne javanica* and relative fresh top weight and root weight (y) of common bean plants cv. Talento grown in pots in a greenhouse.

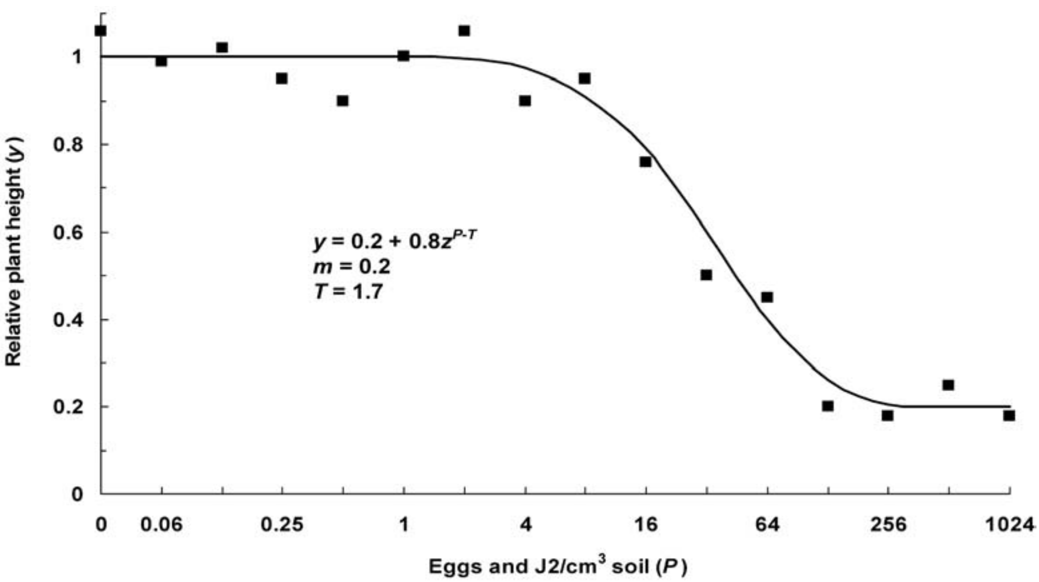

Fig. 2. Relationship between initial population densities (*P*) of the Italian population of *Meloidogyne javanica* and relative height (*y*) of common bean plants cv. Talento grown in pots in a greenhouse.

Our results confirm that the Italian population of *M. javanica* is highly pathogenic to common bean (Sharma, 1981). Reduction in top plant growth began at *P* levels as low as 0.6 eggs of the nematode/ cm^3 soil, and growth reduction was 50% at $P = 16$ eggs and J2/cm^3 soil. Plant growth was severely reduced a $P = 64$ eggs and J2/ cm^3 soil. These results are similar to those obtained with host race 1 of *M. incognita* (Di Vito *et al.*, 2004). To avoid yield losses of common bean in sandy soils infested by *M. javanica*, the nematode soil population densities must be reduced to non-damaging levels (4 eggs and J2/cm^3 soil) before planting. Nematicides and solarization (Greco *et al.*, 1998; Sikora *et al.*, 2005) would effectively control root-knot nematodes, but they may not always be convenient or economically feasible. Although many tolerant or resistant cultivars of common bean to *M. incognita* and *M. javanica* are available (McSorley *et al.*, 1981; Omwega *et al.*, 1989; Mullin *et al.*, 1991; Sydenham *et al.*, 1996), unfortunately they are not suitable for the Italian market. A breeding program to introgress resistance to root-knot nematodes in common bean cultivars suitable for Italian market has been recently funded by the Italian Agriculture Minister (MiPAAF). The objectives of this program include the introgression of resistance to *Meloidogyne* spp. and other pests and diseases that affect the production of Italian common bean cultivars. Some inbred lines of common bean resistant to *Meloidogyne* spp. have been released and made available to the Italian market (Di Vito *et al.*, 2005, 2005a; Parisi *et al.*, 2007). Management procedures need to be implemented in order to guarantee production of common bean, because plant growth reduction can start at soil population densities as low as 0.6 eggs and J2/cm^3 soil. Single and combination strategies that reduce populations below damaging levels, or prevent these nematodes from infesting common bean-growing fields should be

Table 1. Effect of initial population densities (*P*) of *Meloidogyne javanica* at sowing on final population densities, reproduction rate, and root gall index of the nematode on common bean plants cv. Talento grown in pots.

Eggs and J2/cm³ soil		Reproduction rate	Root gall index
Initial population density (*P*)	Final population density (*Pf*)	(*Pf/P*)	(0-5)[y]
0.0625	12.7	203.2 cd[z]	0.8 a
0.125	38.8	307.2 d	1.3 a
0.25	68.3	273.2 d	2.2 b
0.5	95.0	190.0 bcd	2.8 b
1	105.8	105.8 abc	2.8 b
2	160.1	80.0 ab	4.2 c
4	208.3	52.1 a	4.5 cd
8	397.3	49.7 a	4.4 cd
16	675.0	42.2 a	4.5 cd
32	781.2	24.4 a	4.2 c
64	769.1	12.0 a	4.8 cd
128	1180.5	9.2 a	5.0 d
256	99.1	0.4 a	5.0 d
512	15.7	0.03 a	5.0 d
1024	18.3	0.02 a	—

[y]0 = no gall, 1 = 1-5 small galls, 2 = 6-20 small galls, 3 = more than 20 small galls, 4 = root system with several large galls, and 5 = root system completely deformed with few large galls.
[z]Means sharing a letter are not significantly different according to Duncan Multiple's Range Test ($P \leq 0.05$).

used, such as use of nematicides, soil solarization and resistant cultivars. These results provide important and useful information to the extension services and farmers including threshold or tolerance limits (*T*), curve of the nematode damage (from the tolerance limit to minimum yield (*m*) and minimum yield (*m*) of susceptible cultivars of common bean, and population dynamics of the nematode on the crop. They are of fundamental importance in choosing nematode control strategies.

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LITERATURE CITED

Coolen, W. A. 1979. Methods for extraction of *Meloidogyne* spp. and other nematodes from roots and soil. Pp. 317-330 *in* F. Lamberti and C. E. Taylor, eds. Root-Knot Nematodes (*Meloidogyne* species) Systematics, Biology and Control. Academic Press, New York, NY, U.S.A.

Crozzoli, R., N. Greco, C. Andrey Suarez, and D. Rivas. 1997. Pathogenicity of the root-knot nematode, *Meloidogyne incognita*, to cultivars of *Phaseolus vulgaris* and *Vigna unguiculata*. Nematropica 27:61-67.

Di Vito, M., F. Lamberti, and A. Carella. 1979. La resistenza del pomodoro ai nematodi galligeni: prospettive e possibilità. Rivista di Agronomia 13:313-322.

Di Vito, M., N. Greco, and A. Carella. 1985. Population densities of *Meloidogyne incognita* and yield of *Capsicum annuum*. Journal of Nematology 17:45-49.

Di Vito, M., N. Greco, and A. Carella. 1986. Effect of *Meloidogyne incognita* and importance of the inoculum on the yield of eggplant. Journal of Nematology 18:487-490.

Di Vito, M., B. Parisi, and F. Catalano. 2004. Effect of population densities of *Meloidogyne incognita* on common bean. Nematologia Mediterranea 32:81-85.

Di Vito, M., B. Parisi, A. Carboni, and F. Catalano. 2005. Breeding of common bean for resistance to *Meloidogyne* spp. Nematropica 35:70.

Di Vito, M., B. Parisi, A. Carboni, P. Ranalli, and F. Catalano. 2005a. Response of common bean (*Phaseolus vulgaris*) to Italian population of four species of *Meloidogyne*. Nematologia Mediterranea 33:19-23.

Greco, N., F. Lamberti, A. Brandonisio, and P. De Cosmis. 1998. Control of root-knot nematodes on zucchini and string beans in plastic house. Nematologia Mediterranea 26:39-44.

FAO, 2007. Faostat, FAO, Rome, Italy (http://faostat.fao.org/site/336/defauld.aspx).

Hussey, R. S., and K. R. Barker. 1973. A comparison of methods of collecting inocula of *Meloidogyne* spp., including a new technique. Plant Disease Reporter 57:1025-1028.

McSorley, R., K. Pohronezny, and W. M. Stall. 1981. Aspect of nematode control on snap bean with emphasis on relationship between nematode density and plant damage. Proceedings of the Florida State Horticultural Society 94:134-136.

Mullin, B. A., G. S. Abawi, M. A. Pasto-Corrales, and J. L. Kornegay. 1991. Reactions of selected bean pure lines and accessions to *Meloidogyne* species. Plant Disease 75:1212-1216.

Omwega, C. O., I. J. Thomason, P. A. Roberts, and J. G. Waines. 1989. Identification of new sources of resistance to root-knot nematodes in *Phaseolus*. Crop Science 29:1436-1468.

Parisi, B., M. Di Vito, A. Carboni, T. Baschieri, F. Del Bianco, F. Catalano, and P. Ranalli. 2007. Introgressione di resistenza a nematodi galligeni in fagiolo comune da coltura protetta. Agroindustria 2007.

Sasser, J. N., and D. W. Freckman. 1987. A world perspective on nematology: the role of the society. Pp. 7-14 *in* J. A. Veech and D. W. Dickson, eds. Vistas on Nematology. E.O. Painter Printing Co., DeLeon Springs, FL, USA.

Seinhorst, J. W. 1965. The relationship between nematode density and damage to plants. Nematologica 11:137-154.

Seinhorst, J. W. 1979. Nematodes and growth of plants: formulation of the nematode-plant system. Pp. 231-256 *in* F. Lamberti and C. E. Taylor, eds. Root-Knot Nematodes (*Meloidogyne* species) Systematics, Biology and Control. Academic Press, New York NY, U.S.A.

Sharma, R. D. 1981. Pathogenicity of *Meloidogyne javanica* to bean (*Phaseolus vulgaris* L.). Società Brasileira de Nematologia 5:137-144.

Sikora, R. A., N. Greco, and J. F. V. Silva. 2005. Nematode parasites of food legume. Pp. 259-318 *in* M. Luc, R. A. Sikora and J. Bridge, eds. Plant Parasitic Nematodes in Subtropical and Tropical. CAB International, Wallingford, U.K.

Sydenham, G. M., R. McSorley, and R. A. Dunn. 1996. Effects of resistance in *Phaseolus vulgaris* on development of *Meloidogyne* species. Journal of Nematology 28:485-491.

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