RESEARCH NOTE/NOTA INVESTIGATIVA

HOST SUSCEPTIBILITY OF *HORDEUM VULGARE* TO *MELOIDOGYNE GRAMINICOLA*

C. Bellé[1,2]*, R. F. Ramos[1], T. E. Kaspary[3], M. F. Dossin[1], A. L. Brida[4], and Z. I. Antoniolli[1]

[1]Universidade Federal de Santa Maria, Centro de Ciências Rurais, Santa Maria, Rio Grande do Sul, Brasil; [2]Phytus Group, Estação experimental de Itaara, Itaara, Rio Grande do Sul, Brasil; [3] Instituto Nacional de Investigación Agropecuaria -INIA La Estanzuela, Colonia, Uruguay; 4 Faculdade de Administração e Ciências Contábeis, Campo Mourão, Paraná, Brasil; *Corresponding author: crbelle@gmail.com

ABSTRACT

Bellé, C., R. F. Ramos, T. E. Kaspary, M. F. Dossin, A. L. Brida, and Z. I. Antoniolli. 2020. Host susceptibility of *Hordeum vulgare* to *Meloidogyne graminicola*. Nematropica 50:96-100.

Barley (*Hordeum vulgare*) is an important crop used for human consumption and mainly by the malt industry. Recently, a species of the root-knot nematode (*Meloidogyne graminicola*) was found and recorded to parasitize barley roots in Brazil. In this context, the objective of this work was to evaluate the susceptibility of 17 barley genotypes to *M. graminicola* in the greenhouse. Barley genotypes were individually inoculated with 5,000 eggs + second stage juveniles (J2) of *Meloidogyne* and kept in a greenhouse. After 60 days, the roots of each plant were evaluated for gall number, number of nematodes per root gram and reproduction factor (RF = final population / initial population). All barley genotypes evaluated behaved as susceptible to *M. graminicola*. The cultivar 'Scarlett' had the lowest RF (14.9), while the 'BRS Itanema' resulted in the highest RF (24.5).

Key words: Barley, root-knot nematode, reproduction, susceptibility

RESUMO

Bellé, C., R. F. Ramos, T. E. Kaspary, M. F. Dossin, A. L Brida, and Z. I. Antoniolli. 2020. Suscetibilidade de *Hordeum vulgare* a *Meloidogyne graminicola*. Nematropica 50:96-100.

A cevada (*Hordeum vulgare*) é uma importante cultura utilizada na alimentação humana e principalmente pela indústria de maltes. Recentemente, uma espécie do nematoide-das-galhas (*Meloidogyne graminicola*) foi encontrada e registrada parasitando raízes de plantas de cevada no Brasil. Nesse contexto, o objetivo do trabalho foi avaliar, em casa de vegetação, a suscetibilidade de 17 cultivares de cevada a *M. graminicola*. As cultivares de cevada foram individualmente inoculadas com 5.000 ovos + juvenis do segundo estádio (J2) de *Meloidogyne* mantidas em casa de vegetação. Após 60 dias, as raízes de cada planta foram avaliadas quanto ao número de galhas, população final e fator de reprodução (FR=população final/população inicial). Todas as cultivares de cevada avaliadas comportaram-se como suscetíveis a *M. graminicola*. A cultivar 'Scarlett' apresentou o menor FR (14,9), enquanto que a 'BRS Itanema' resultou no maior FR (24,5).

Palavras chave: Cevada, nematoide-das-galhas, reprodução, suscetibilidade

Barley (*Hordeum vulgare* L.) is a winter cereal grown in various regions of the world. Cultivation is concentrated in the Brazilian Southern Region, being predominantly used for

malt production in the brewing industry (Mori and Menella, 2012). The cultivation of this cereal is dependent on several biotic and abiotic factors. Pathogens and pests are some of the main biotic factors responsible for crop yield and quality losses, causing economic loss to the barley agroindustry.

Due to barley's great agronomic relevance in the world, the genome of this cereal has been recently sequenced, mapped, and made available (Ariyadasa *et al.*, 2014). At the same time, the mechanisms of resistance to pests and pathogens for barley are of great interest to the scientific community and are being elucidated (Andersen *et al.*, 2016). From an agronomic perspective, studies to assess the susceptibility of barley to pests and diseases represent an open field of research for several emerging diseases.

Recently, the first case of *Meloidogyne graminicola* in barley was detected in commercial cultivation in southern Brazil (Bellé *et al.*, 2019a). The importance of this pathogen for barley production should be determined for Brazil because *M. graminicola* is a species of root-knot nematode known to cause significant yield losses in rice (*Oryza sativa*), another economically important crop in southern Brazil (Negretti *et al.*, 2017). However, the response of barley genotypes to *M. graminicola* is unknown.

Evaluating the reproduction of *M. graminicola* in different genotypes of barley may indicate nematode host cultivars, contribute to the detection of resistant genotypes, and provide tools for nematode management programs in cultivated areas. Thus, the objective of this work was to evaluate the variability of 17 barley genotypes regarding resistance and/or susceptibility of *M. graminicola*.

During the months of April and May 2019, a greenhouse test was conducted to evaluate the reaction of 17 barley genotypes (ANA 02, ANAG 01, BRS 195, BRS Aurine, BRS Brau, BRS Elis, BRS Itanema, BRS Korbel, BRS Manduri, BRS Marciana, BRS Quaranta, BRS Sampa, BRS Timbauva, Danielle, MN 6021, Scarlett) to *M. graminicola*. The experimental design was a completely randomized design with 10 replicates. The average daily temperatures inside the greenhouse ranged from 20.5 to 27.5°C.

Individual barley plants of the different genotypes, four days after emergence, were transplanted to pots (2,000 cm^3) containing sterile substrate (mixture of sand and soil 2:1). Five days after transplanting the seedlings, each pot was infested with a suspension of 5,000 eggs + second stage juveniles (J2) of *M. graminicola* (initial population). Eggs and juveniles were obtained according to the method of Hussey and Barker (1973) as modified by Bonetti and Ferraz (1981). The rice cultivar BR-IRGA 410 was used as a control treatment. The population of *M. graminicola* used was isolated from barley roots (BRS Brau) from Santa Maria (RS) (Bellé *et al.*, 2019a) and multiplied in rice 'BR IRGA 410'.

The soil used in the experiment is classified as Planossolo Hidromórfico Eutrófico Arênico, according to the Brazilian Soil Classification System (Santos *et al.*, 2018), with the following characteristics: clay = 34%; water pH value= 5.9; SMP index = 6.3; organic matter= 3.8%; phosphorus = 12.2 mg dm-3; potassium= 68 mg dm-3; calcium= 6.8 cmolc.dm-3 magnesium = 2.7 cmolc.dm-3; and sulfur= 3.4 cmolc.dm-3.

Sixty days after inoculation, each root system was washed under tap water, weighed after removing excess water with paper towels, and number of galls were counted. The gall number per root system was assessed and after counting the gall number, the root systems were processed following the method of Hussey and Barker (1973), using a 0.5% sodium hypochlorite solution to triturate the roots in a blender to obtain the final suspension for nematode population quantification. This number was used to obtain the reproduction factor (RF = final population (Pf)/initial population (Pi)), as methodology proposed by Oostenbrink (1966), where the barley genotypes were classified as RF <1.00 for resistant and RF>1.00 for susceptible. In addition, the number of nematodes per gram of root was estimated, which is defined by the ratio between the total number of nematodes and the total mass of the roots in grams of each replicate. Data obtained were analyzed for normality by the Shapiro-Wilk test, to homoscedasticity by the Hartley test and subsequently analyzed of variance, and the treatments means were compared by the Scott-Knott at a significance level of 5% with SISVAR software (Ferreira, 2011).

All barley genotypes evaluated were susceptible (RF> 1.00) to *M. graminicola* (Table 1). However, different levels of susceptibility were observed among the 17 barley genotypes. The rice plants used as control in the inoculum viability

Table 1 – Gall numbers (GN), number of nematodes per root gram (NNRG) and reproduction factor (RF) of *Meloidogyne graminicola* in different barley genotypes.

Genotypes	GN	NNRG[v]	RF[w]	Reaction[x]
ANA 02	310 c[y]	4261 a	18.6 b	S
ANAG 01	301 c	3504 b	17.7 b	S
BRS 195	317 c	4099 a	18.6 b	S
BRS Aurine	272 c	4202 a	19.7 b	S
BRS Brau	306 c	4009 a	18.9 b	S
BRS Cauê	301 c	3530 b	17.9 b	S
BRS Elis	291 c	3811 a	18.1 b	S
BRS Itanema	288 c	4759 a	24.5 a	S
BRS Korbel	360 b	2489 b	16.6 c	S
BRS Manduri	392 a	3123 b	17.2 b	S
BRS Marciana	387 a	3462 b	16.8 c	S
BRS Quaranta	345 b	2779 b	16.3 c	S
BRS Sampa	336 b	3178 b	16.5 c	S
BRS Timbaúva	353 b	2681 b	15.8 c	S
Danielle	284 c	2926 b	13.7 d	S
MN 6021	295 c	2630 b	14.5 d	S
Scarlett	262 c	3183 b	14.9 d	S
BR IRGA 410 (Rice)[z]	572 -	7455 -	37.5 -	S
CV (%)	12.5	21.91	9.55	-

[v]Number of nematodes per gram of root: ratio between total nematodes and total root mass
[w]RF = Final population/Initial population
[x]Reaction: resistant (R) (RF <1.0) e susceptible (S) (RF > 1.0)
[y]Means followed by different lowercase letters in the column differ from one another by the Scott-Knott group ($p \leq 0.05$), comparing the genotypes
[z] Susceptible control

verification presented an average RF value = 37.5, confirming the inoculum viability used in the experiment.

In determining of the gall numbers of *M. graminicola* by barley root system, the genotypes with the highest gall numbers were 'BRS Manduri' and 'BRS Marciana', which ranged from 387 to 392, respectively. The genotypes 'Scarlett', 'BRS Aurine', 'Danielle', 'BRS Itanema', 'BRS Elis', 'MN 6021', 'ANAG 01', 'BRS Cauê', 'BRS Brau', 'ANA 02' and 'BRS 195' resulted in the lowest mean values for gall numbers (Table 1).

Regarding the number of nematode per gram of roots in barley, the genotypes with the lowest absolute values were 'BRS Korbel', 'MN 6021', 'BRS Timbaúva' and 'BRS Quaranta' with NNGR of 2489, 2630, 2681 and 2779, respectively (Table 1). Values of NNGR above 4,000 were observed for 'BRS Elis', 'ANA 02', 'BRS 195', 'BRS Aurine', 'BRS Brau', and 'BRS Itanema' (Table 1). However, when compared to the control, the values found for barley were lower in all evaluated genotypes, evidencing a clear effect of species regarding the parasitism capacity of this plant-parasitic nematode on barley.

The reproduction factor of *M. graminicola* for the different barley genotypes evaluated showed that the genotype “BRS Itanema” showed higher nematode multiplication, with RF of 24.5 (Table 1). The genotypes 'Danielle', 'MN 6021', and 'Scarlett' showed the lowest values for RF, with values of 13.7, 14.5 and 14.9, respectively. The other genotypes showed intermediate behavior for reproduction factor, with values ranging from 16.3 to 19.7 (Table 1). It is important to highlight the differential parasitism capacity of *M. graminicola* in relation to the evaluated genotypes, although they were susceptible, there was great variability in the response of these materials, which may be the first step to identify less susceptible genotypes.

The results show that all barley genotypes tested behaved as susceptible to this plant-parasitic nematode (Table 1). The susceptibility of genotypes to *M. graminicola* is an important

indicator of the need for other control measures, since such species are widespread in the cultivation areas. Although several management strategies are used to increase crop productivity, none have been fully effective in keeping populations below the level of economic damage (Fernandes *et al.*, 2013). Studies of genetic resistance are important from the point of view of control of plant-parasitic nematode since the responses to these pathogens are reproduced in these hosts. In this sense, M. *graminicola* multiplication in barley generally occurs rapidly, reaching high levels in a short time.

Even though the data obtained with the present work show that all evaluated barley genotypes are susceptible to *M. graminicola*, the use of less susceptible genetic materials, as observed in this study, combined with alternative management practices, may contribute to increased crop productivity. These measures include the incorporation of organic matter into the system, the use of antagonistic plants, biological control, crop rotation with non-host plants, and combining the application of systemic nematicides together with seed treatment. Another important factor to be considered in the management of this plant-parasitic nematode is the already proven ability to parasitize and cause serious damage to a rice crop, making it impossible to use rice in a crop rotation system, or at least those susceptible cultivars (Kumar and Singh, 2011; Bellé *et al.*, 2019b). The use of these techniques together can contribute decisively to the reduction of the population of *M. graminicola* in barley cultivation areas, in order to minimize the problems caused by such pathogens and, consequently, increase the crop productivity.

LITERATURE CITED

Andersen, E. J., S. Ali, R. N. Reese, Y. Yen, S. Neupane, and M. P. Nepal. 2016. Diversity and evolution of disease resistance genes in barley (*Hordeum vulgare* L.). Evolutionary Bioinformatics 4:99-108.

Ariyadasa R., M. Mascher, T. Nussbaumer, D. Schulte, Z. Frenkel, N. Poursarebani, R. Zhou, B. Steuernagel, H. Gundlach, S. Taudien, M. Felder, M. Platzer, A. Himmelbach, T. Schmutzer, P. E. Hedley, G. J. Muehlbauer, U. Scholz, A. Korol, K. F. Mayer, R. Waugh, P. Langridge, A. Graner, and N. Stein. 2014. A sequence-ready physical map of barley anchored genetically by two million single-nucleotide polymorphisms. Plant Physiology 164:412-23.

Bellé, C., R. R. Balardin, D. Dalla Nora, J. Schmitt, M. Gabriel, R. F. Ramos, and Z. I. Antoniolli. 2019a. First Report of *Meloidogyne graminicola* (Nematoda: Meloidogynidae) on barley (*Hordeum vulgare*) in Brazil. Plant Disease 103:1045.

Bellé, C., R. F. Ramos, R. R. Balardin, T. E. Kaspary and A. L. Brida. 2019b. Reaction of rice cultivars to *Meloidogyne graminicola* as a function of irrigation management. Communications in Plant Sciences, 9:124-128

Bonetti, J. I., and S. Ferraz. 1981. Modificações do método de Hussey & Barker para extração de ovos de *Meloidogyne exigua* em raízes de cafeeiro. Fitopatologia Brasileira 6:553.

Fernandes, R. H., E. A. Lopes, B. A. Vieira, and A. F. Bontempo. 2013. Controle de *Meloidogyne javanica* na cultura do feijoeiro com isolados de *Bacillus* spp. Revista Trópica – Ciências Agrárias e Biológicas 7:76-81.

Ferreira, D. F. 2011. Sisvar: a computer statistical analysis system. Ciência e Agrotecnologia 35:1039-1042.

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

Kumar, N., and K. P. Singh. 2011. Use of *Dactylaria brochopaga*, a predacious fungus, for managing root-knot disease of wheat (*Triticum aestivum*) caused by *Meloidogyne graminicola*. Mycobiology 39:113-117.

Mori, C., and E. Minella. 2012. Aspectos econômicos e conjunturais da cultura da cevada. Documentos Embrapa Trigo,139:1-20.

Negretti, R. R. D., C. B. Gomes, V. S. Mattos, L. Somavilla, R. Manica-Berto, D. Agostinetto, P. Castagnone-Sereno and R. M. D. G. Carneiro. 2017. Characterisation of a *Meloidogyne* species complex parasitizing rice in southern Brazil. Nematology 19:403-412.

Oostenbrink, M. 1966. Major characteristics of the relation between nematodes and plants. Mededelingen, Van De Landbouwhogeschool 66:1-46.

Santos, H. G., P. K. T. Jacomine, L. H. C. Anjos, V. A. Oliveira, J. F. Lumbreras, M. R. Coelho,

J. A. Almeida, J. C. Araujo Filho, J. B. Oliveira, and T. J. F. Cunha. 2018. Sistema Brasileiro de Classificação de Solos. Brasília: Embrapa Solos, 374 p.

Received: *11/VII/2019*
Accepted for publication: *2/IX/2020*
Recibido:
Aceptado para publicación: