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RELATIONSHIP BETWEEN POPULATION DENSITIES OF *Globodera rostochiensis* AND YIELD OF POTATO CULTIVARS UNDER FIELD CONDITIONS IN BULGARIA

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In 2010–2011, in field conditions (Smolyan potato growing region) microplots experiment have been carried out to determine the effect of population densities of *Globodera rostochiensis* pathotyp 3 (Ro3) on the growth and yield of two new Bulgarian potato (*Solanium tuberosum L.)* varieties Evridika and Orfei. Microplots were 25 cm-diam. 30 cm-deep, filled with 10 L of soil infested with *G. rostochiensis* in a geometric series of nematode densities between 0 and 64 eggs/mL of soil. Eight weeks after planting in infested soil, the relative plant height of varieties Evridika and Orfei was reduced at Pi ≥ 1 and 32 eggs/mL soil, respectively. In both potato varieties the minimum possible relative values for plant height were 0,51 and 1,0, respectively, at Pi = 64 eggs/mL soil. The tolerance limits of potato yield of Evridika and Orfei were 2 and 16 eggs/mL soil, respectively. The minimum possible relative values for yield of Evridika and Orfei were 0,325 kg/plant and 0,659 kg/plant, respectively, at Pi = 64 eggs/mL soil. A mathematical model describing the influence of Pi of *G. rostochiensis* and yield of both varieties can be used in expert advisory systems when accounting for the environmental factors.

Keywords: potato cyst nematode, *Solanum tuberosum L.*, pathogenicity, potato, *Globodera rostochiensis*, tolerance limit, yield losses.

The potato cyst nematode *Globodera rostochiensis* (Woll.) Behrens is among the most damaging nematodes of potatoes worldwide [12]. In Bulgaria, a former species appears all over the country [5]. Microplot experiments [2] demonstrated an average tolerance limit of potato to *G. rostochiensis* of 2 eggs/g soil and that yield losses of 62 % would occur when cultivating potatoes in fields infested with 64 eggs/g soil, respectively.

Although crop rotation and nematodocides are effective, the use of resistant potato cultivars is the most promising way of controlling these plant parasitic nematodes. However, most of the available potato cultivars resistant to potato cyst nematodes are resistant only to pathotype Ro1 of *G. rostochiensis*, with few also resistant to other pathotypes [5, 13]. In Bulgaria, the most widespread pathotypes of *G. rostochiensis* is Ro1 and then Ro3 [6]. The diverse and often extreme climatic conditions of individual regions, the high infectious background in the country and the low propagation coefficient of tie crop impose the use of a great set of cultivars. These factors limit the realization of higher and stable potato production and require the creation of more productive varieties, characterized by early and intensive tuber formation, high genetic potential for yield, resistance to these economically important parasite and ecological stress.

In previously our study a two new varieties Evridika and Orfei, suitable for potato cultivation in South-West Bulgaria, bred at the Maritsa Vegetable Crops Research Institute, the former varieties was considered the susceptible to *G. rostochiensis* Ro3 and the latter resistant – to Ro3 of this parasite in chamber room experiment at initial population density 12 eggs/g soil (Samaliev`s unpublished data). Experiments assessing impact of different population densities of *G. rostochiensis* Ro3 on the yield are lacking.

The aim of the present investigation was undertaken to study the effect of population densities of *G. rostochiensis* Ro3 on the growth of both new potato varieties Evridika and Orfei.

Materials and methods

Plant material. *Solanum tuberosum* L., was developed within the potato breeding program carried out at the Maritsa Vegetable Crops Research Institute, Plovdiv, Bulgaria. To produce tubers, plants were grown in experimental field in Pavelsko (Smolian potato growing region) during the 2010, using the standard potato field procedures for the area.

The experiments were conducted during 2011 at Pavelsko in a field with a loamy sandy soil (sand 80 %). One hundred microplots (25 cm in diameter and 30 cm long) disposed so as to stick out 8 cm from the soil. Ten liters of soil, infested at the appropriate nematode density, was added to fill the microplots to within 5 cm of the upper edge of the microplot rim.

The population of *G. rostochensis* (location Smolyan), previously identified as pathotype Ro3 [3] used in this tests were reared on the susceptible potato cultivar Cosmos in plastic pots in a glasshouse. The cysts were extracted from dried soil using a Fenwick can [9], dried and thoroughly mixed with of river sand. The nematode population density in the medium was estimated as described in Samaliev and Nacheva [6]. Appropriate amounts of infested soil and fertilizers were then thoroughly mixed with loamy sandy soil that had been fumigated with Basamid Granulat 2 months earlier to provide initial population density (Pi) of *G. rostochiensis* of 0; 0,5; 1; 2; 4; 8; 16; 32 or 64 eggs per mL soil. In each experiment there were 4 replicates per inoculum level in a randomized block design. The seed tubers (variety Evridika and variety Orfei) had been chatted to have sprouts approximately 1 cm long. Great care was taken in selecting equal weights of healthy tubers for each pot during planting on 26 April.

Microplots received routine cultural practices during the experiments. During the potato vegetation shoot emergence, foliar symptoms and plant height were recorded. The haulm was destroyed on 23 September and at harvest on 6 October the each plant were hand dug and the total weight of tubers recorded.

Statistical analysis: we applied the analysis of variance, using procedures of the programs: SPSS 12.0, Microsoft Excel and Table Curve.

Results and discussion

Inoculum levels of *G. rostochiensis* did not influence on plant emergence. However, the symptoms of nematode infection (stunting, yellowing and senescence of the plants) in microplots planted with susceptible variety Evridika were obvious after five, four and tree weeks in variants inoculated with Pi $\geq$ 16, 32 and 64 eggs/mL soil, respectively. The microplots planted with the resistant potato variety Orfei showed negligible reduction of growth even at large inoculum levels as 64 eggs/mL soil. Eight weeks after planting in infested soil, the relative plant height of varieties Evridika and Orfei was reduced at Pi $\geq$ 1 and 32 eggs/mL soil, respectively. In both potato varieties the minimum possible relative values for plant height were 0,51 and 1,0, respectively, at Pi = 64 eggs/mL soil (fig. 1).

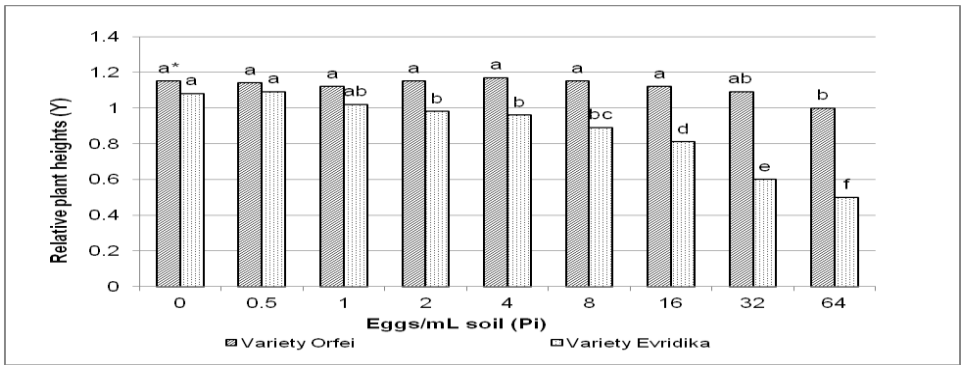

Fig. 1. Relative height of potato plants (Y) of susceptible variety Evridika and partially resistant variety Orfei grown in microplots with different population densities of *Globodera rostochiensis* Ro3 in experimental field in region Pavelsko, eight weeks after planting (The mean values with different letters have significant difference ($P_{0,05}$) according to Duncan's Multiple Range Test)

The tolerance limits of potato yield of Evridika and Orfei were Pi of *G. rostochiensis* ≥ 2 and 32 eggs/mL soil, respectively. The minimum possible relative values for yield of Evridika and Orfei were 0,325 kg/plant and 0,659 kg/plant, respectively, at Pi = 64 eggs/mL soil (fig. 2).

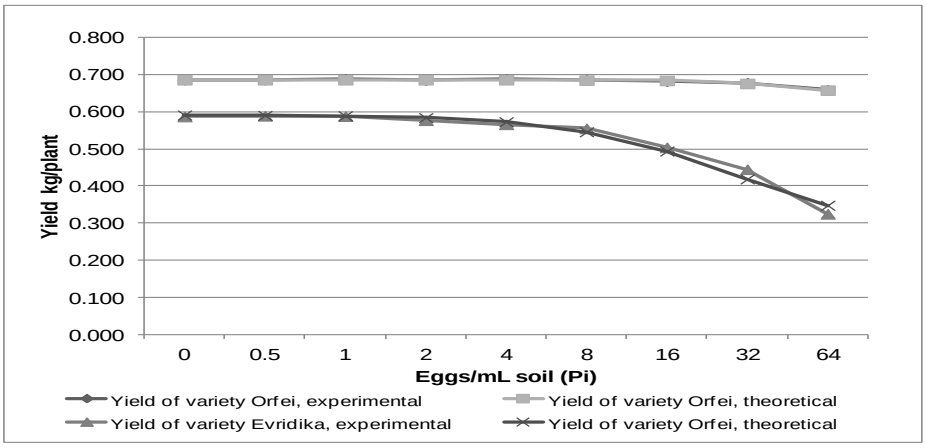

Fig. 2. Relationship between initial population densities *(Pi)* of *Globodera rostochiensis* Ro3 at planting and relative yield (*Y*) of susceptible variety Evridika and partially resistant variety Orfei

The tolerance limit to Bulgarian population of *G. rostochiensis* and the minimum relative yield of susceptible variety Evridika were very close to those obtained in microplots with susceptible variety Nadezda [4]. The resistant potato variety Orfei showed promise where the Pi of *G. rostochiensis* was in the range 32–64 eggs/mL soil, which are the much more high than frequent infestation levels (4–16 eggs/mL eggs/mL) found in the fields [3].

The statistical processing of the experimental data demonstrated high coefficient of correlation (r^2 = 0,99 and 0,96) between Pi of *G. rostochiensis* and yield of varieties Orfei and Evridika (tab. 1). A mathematical model describing the influence of Pi of *G. rostochiensis* and yield of both varieties described by the following equation:

$Y = a + b / [1 + (x / c)^d$, were relative yield (*Y*) and $x = \log (Pi)$

In the carried out linear regression analysis a model were established with empirically counted parameters of the equation which most precisely correspond to the experimental data (fig. 2, tab. 1).

1. An estimate of the parameters with the mathematical model describing the relationship between the yield and the initial population density (P i) of *Globodera rostochiensis* Ro3 with two potato varieties (Orfei and Evridika)

Variety (equation)	Coefficients				Stat. characteristics	
	a	b	c	d	r^2	Fit Std. err.
Orfei	0,6000	0,0864	96,4728	1,8941	0,990	0,0014
Evridika	0,5914	– 0,3189	28,3154	–1,4279	0,965	0,0176

The application of one of the so far offered models does not give a guarantee for obtaining equally good results in all varieties and is also connected with necessity of experimental data especially if a population of *G. rostochiensis* is studied in another country [7, 8, 11]. With the both Evridica and Orfei the relationship between the Pi and the yield is best described by a mathematical model with an equation [1]. All parameters of the equations counted empirically with a computer program on the basis of the experimental data and obtained for the respective variety may be used for prognostication of the yield.

The resultant equation may be used in an expert advisory system for prognostication of the yields. There is evidence that the degree to which tolerance of *G. rostochiensis* is expressed whether measured by rate of yield loss, proportional yield loss or minimum yield, varies with the environment (the influence of abiotic factors, fertilization, soil type etc.) in which the crop is grown [7, 10, 11]. That is why in creating similar systems relationships have to be included expressing the influence of these factors.

Growth reduction of potato plants of variety Evridika were obvious after five, four and three weeks in variants inoculated with Pi of *G. rostochiensis* Ro3 $\geq$ 16, 32 and 64 eggs/mL soil, respectively. The micropots planted with the resistant potato variety Orfei showed negligible reduction of growth even at large inoculum levels as 32 eggs/mL soil. The Pi of *G. rostochiensis* which causes decrease in the yield were 2 eggs/mL soil for the susceptible variety Evridika and for the resistance variety Orfei were 32 eggs/mL soil. From the tested varieties the highest yields at lower Pi of *G. rostochiensis* (Pi < 32 eggs/mL) gave the Orfei. In order to take optimal decisions when potato varieties are included in rotation with non host crops it is necessary for them to be tested beforehand. The mathematical model describing the relation between Pi of *G. rostochiensis* and yield can be used in expert advisory systems when accounting for the environmental factors.

References

1. *Dale M.F.B., Phillips M.S., Ayres R.M. et al.* The assessment of tolerance of partially resistant potato clones to damage by the potato cyst nematode *Globodera pallida* at different sites and in different years // Ann. of Applied Biol. – 1988. – V. 113. – P. 79–88.

2. *Turner S.J. and Evans K.* The origins, global distribution and biology of potato cyst nematodes (*Globodera rostochiensis* (Woll.) and *Globodera pallida* Stone / In: Potato Cyst Nematodes: Biology, distribution and control (Marks R.J. and Brodie B.B., eds). CAB International, Wallingford, UK. – 1998. – P. 7–26.

3. *Samaliev H.* Plant parasitic nematodes on potato. Biology, distribution and control / In: Samaliev H. and Stoyanov D. (eds.). Parasitic Nematodes of Crop Plants and Their Control. Agricultural academic press, Plovdiv. – 2007. – P. 197–208.

4. *Samaliev H.Y.* Pathotypes of Cysts Nematodes *Globodera rostochensis* and *Globodera pallida* (Heteroderidae:Nematoda) on Potato in Bulgaria.// International scientific on-line Journal, «Science & technologies», Plant science. – 2011. – V. 1. – P. 11–14.

5. *Samaliev H., Grigorov P., Samalieva A.* Relationship between the initial and final population density of *Globodera rostochiensis* Well. on susceptible and resistant potato cultivars // Acta Hort. – 1998. – V. 462. – P. 973–976.

6. *Samaliev H., Stoyanov D.* Parasitic Nematodes of Crop Plants and Their Control. – Plovdiv: Agricultural academic press, 2007. – 328 pp.

7. *Samaliev H., Nacheva E.* Screening of Tetraploid Clones and Varieties with Different Genetic Backgrounds for Resistance to Potato Cyst Nematodes, *Globodera rostochiensis* and *G. pallida* // J. of Bul. Ecology. – 2011. – V. 14. – P. 405–413

8. *Seinhorst J.W.* The relationship in field experiments between population density of *Globodera rostochiensis* before planting potatoes and yield of potato tubers // Nematologica. – 1982. – V. 28. – P. 277–284.

9. *Seinhorst J.W., Ouden H.* An improvement of Bijloo's method for determining the egg content of Heterodera cysts // Nematologica. – 1966. – V. 12. – P. 170–171.

10. *Shepher A.M.* Extraction and estimation of cyst nematodes / In: Laboratory methods for work with plant and soil nematodes (Southey J.F., eds.). Technical bulletin No. 2, 6th edition, Ministry of Agriculture, Fisheries and Food, London, UK, 1986. – P. 31–49.

11. *Trudgill L.* Yield losses caused by potato cyst nematodes: a review of the current position in Britain and prospects for improvements // Ann. appl. Biol. – 1986. – V. 108. – P. 181–198.