THE INFLUENCE OF POTATO CYST NEMATODE G. ROSTOCHIENSIS INFESTATION ON DIFFERENT POTATO CULTIVARS

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ABSTRACT

The potato cyst nematode Globodera rostochiensis is one of the most serious pests of potato in Slovenia. Precise nematode identification and knowledge about potato cultivars, which are most suitable for growing in the Slovenian climate conditions and most resistant to G. rostochiensis, are necessary to develop an effective integrated pest control. Here we report the results of the influence of G. rostochiensis pathotype Ro1/4 on the yield of different potato cultivars: the susceptible cultivar Desiree, the resistant cultivars White Lady, Miranda, Aladin, Sante and Adora, and the clone KIS 94-1/5-14. The yield of cv. White Lady was the highest and that of susceptible cv. Desiree the lowest. The influence of several resistant and one susceptible potato cultivars on population dynamics of G. rostochiensis was also determined. The total number of cysts/100 cm^3 and the number of eggs and juveniles per cyst increased in the susceptible cv. Desiree and decreased in the resistant cultivars White Lady, Sante and Adora.

Keywords: Globodera rostochiensis, potato cyst nematodes, PCN, potato, potato cultivars, Slovenia

IZVLEČEK

Rumena krompirjeva ogorčica Globodera rostochiensis je eden najnevarnejših škodljivcev krompirja. Za razvoj integriranega varstva krompirja pred tem škodljivcem so pomembni natančna identifikacija vrste in podatki o možnosti pridelave odpornih sort krompirja na vrsto G. rostochiensis v slovenskih rastnih razmerah. V tem prispevku poročamo o rezultatih študije vpliva vrste G. rostochiensis, Ro1/4 na pridelek različnih krompirjevih sort: Desiree, White Lady, Miranda, Aladin, Sante, Adora in klon KIS 94-1/5-14. Največji pridelek smo ugotovili pri odporni sorti White Lady, najmanjšega pa pri občutljivi sorti Desiree. Pri nekaterih odpornih in eni občutljivi sorti krompirja smo raziskali tudi vpliv sorte krompirja na populacijsko dinamiko vrste G. rostochiensis. Skupno število cist /100 cm^3 in skupno število jajčec in ličink se je povečalo pri občutljivem Desireeju in upadlo pri sortah White Lady, Sante and Adora.

Ključne besede: Globodera rostochiensis, krompirjeve ogorčice, PCN, krompir, sorte krompirja, Slovenija

POVZETEK

Krompir je v Sloveniji pomembna poljščina. Površina, ki mu jo namenjamo ni vedno enaka in se je v zadnjih letih zelo zmanjšala. Po podatkih Statističnega urada Republike Slovenije smo v letu 2005 pridelovali krompir na 6.306 ha oziroma na 3,6% orne površine. Povprečni hektarski pridelek je bil ocenjen na 22,9, skupni pridelek pa na 144.714 t. Krompir je dovzeten za napad različnih rastlinskih bolezni in škodljivcev, med katerimi so izredno nevarne krompirjeve ogorčice (rumena in bela), ki lahko resno ogrozijo nemoteno pridelavo krompirja. Na rumeno krompirjevo ogorčico smo v Sloveniji prvič naleteli leta 1971 v vasi Dobrava pri Dravogradu, kasneje pa še v Libeličah pri Dravogradu leta 1999, Šenčurju pri Kranju leta 2000 ter na Okroglem pri Zlatem polju leta 2003. V letu 2004 smo ugotovili napad G. rostochiensis v Posočju (dolina Trente, Bovško do Kobarida), v letu 2006 pa tudi na območju Čepovana blizu Nove Gorice. Kot varstveni ukrep pred razmnožitvijo in širjenjem krompirjevih ogorčic lahko učinkovito izrabljamo uvajanje odpornih sort krompirja, prilagojenih obstoječim biološkim rasam krompirjeve ogorčice. V okviru tega prispevka smo želeli ugotoviti katere sorte so najbolj ustrezne za podnebne oziroma rastne razmere v dolini Trente, kjer je rumena krompirjeva ogorčica (biološka rasa Ro1/4) v Sloveniji najbolj razširjena. Želeli smo ugotoviti vpliv škodljivca na pridelek krompirja oziroma vpliv preskušanih sort krompirja na populacijo rumene krompirjeve ogorčice. Poskus je potekal na njivi z visoko navzočnostjo cist G. rostochiensis (biološka rasa Ro1/4), zasnovan pa je bil v petih naključnih blokih. V poskusu smo preskusili sedem različnih sort krompirja z različno stopnjo odpornosti na G. rostochiensis: občutljiva sorta Desiree, klon KIS 94-1/5-14 ter na Ro1/4 odporne White Lady, Miranda, Aladin, Sante in Adora. Na koncu rastne sezone (september) smo poskus izvrednotili. Ugotovili smo, da G. rostochiensis ne vpliva le na pridelek krompirja, temveč tudi na kakovost pridelka oziroma na velikost krompirjevih gomoljev. Najbolj se je izkazala sorta White Lady, ki je dala statistično značilno največji pridelek, njej pa so sledile sorte Sante, Miranda, Adora in Aladin. Najslabši pridelek smo ugotovili pri klonu KIS 94-1/5-14 in sorti Desiree. Ugotovili smo tudi, da različne sorte krompirja vplivajo na populacijsko gostoto in vitalnost G. rostochiensis. Medtem, ko se je število cist G. rostochiensis pri sorti Desiree po izkopu krompirja povečalo na 396 % začetne populacije, se je njihovo število pri sortah White Lady, Sante in Adora zmanjšalo na 54 %, 59% oziroma 79% začetne populacije.

1. INTRODUCTION

Potato is an important crop for Slovenian agriculture. It is produced mainly in the lowlands of the northern, north eastern, central and south eastern part of Slovenia. The area which is set aside for potato production has been decreasing since the 1990s. Potato production in Slovenia in 2005 occupied 6.306 ha, which is 3,6% of the arable land (Statistical office of the Republic Slovenia). The official estimate of average yield was 22,9 tons/ha and the total production 144.714 tons in 2005.

As in many other countries of the temperate region, potato is one of the most important foodstuffs also in Slovenia. It is an essential part of every day's diet because of its applicability and its nutritive value. The potato crop is very sensitive to many plant pathogens and diseases such as Synchytrium endobioticum (Schylbersky) Percival, Phytophthora infestans (Mont.) de Bary, Streptomyces scabies (Thaxt.) Waks. Et Henz. , Corynebacterium sepedonicum (Speick.) Dows., Pseudomonas xanthochlora (Schuster) Stapp., Leptinotarsa decemlineata Say, Melolontha melolontha Fabricius, Phthorimaea operculella Zeller, Ditylenchus destructor Thorne, Globodera rostochiensis (Woll.) Behrens, G. pallida (Stone) Behrens, and a number of potato viruses. The potato cyst nematode G. rostochiensis has influenced the potato production in Slovenia since 1971, when it was first discovered in Dobrava near Dravograd [4]. The nematode invades potato roots, causing damage which reduces the root growth, the uptake of nutrients and water, and hence the top growth, light interception and tuber yields [11]. The reduction of yield is proportional to nematode population density at planting [9] but is also affected by environmental factors such as soil type [11].

After the first finding in Dobrava near Dravograd (1971), G. rostochiensis was also found in Libeliče near Dravograd (1999), Šenčur near Kranj (2000), Okroglo near Zlato polje (2003), Žabnica near Kranj (2004), Posočje - the Trenta valley (2004) and Čepovan near N. Gorica (2006). We noted that the distribution of G. rostochiensis coincided with the narrow crop rotation and the reduced crop diversity. Posočje is a typical area where potato is produced mainly in monoculture. Therefore, alternative ways of potato production have been investigated, which could be acceptable for people in that region where the available arable land is very limited.

The aim of our work was to define which potato cultivars are the most suitable for growing in the climate conditions around Posočje and the most resistant to the prevalent G. rostochiensis in the region at the same time. Therefore, a study of the influence of different potato cultivars on the population density and viability of G. rostochiensis field population under these conditions has been carried out.

Table 1: Mean monthly air temperatures (°C) and monthly rainfall sums (mm) in Trenta in 2005 (Environmental Agency of the Republic of Slovenia)

Mean monthly air temperatures (T (°C))												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Spt	Oct	Nov	Dec	Yearly mean air temp..
1.2	-0.5	4.2	9.0	14.9	18.1	19.4	17.6	15.3	10.2	4.0	-1.1	9.3
Monthly rainfall sums (mm)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Spt	Oct	Nov	Dec	Yeraly rainfall sum
3.9	14.4	40.5	162.4	114.6	102.3	224.2	175.6	105.6	176	152.9	146.6	1419

2. MATERIALS AND METHODS

The trial was established in the Trenta valley at the site which was heavily infested with G. rostochiensis (pathotype Ro1/4). Potato has been grown mainly as monoculture on that field. The soil type at the field was defined as rendzik leptosol. The details of the climate (temperatures and monthly rainfall) in the year of the trial are given in Table 1. The complete randomized block design with seven treatments in five repetitions was applied. Seven potato cultivars were chosen that exhibit different degrees of resistance to G. rostochiensis: the standard susceptible cultivar Desiree, which is the prevalent variety in Slovenian potato production, and the resistant cultivars White Lady, Miranda, Aladin, Sante and Adora, and the clone KIS 94-1/5-14. The resistance data were published by Polgar et al. for cv. White Lady and by NIVAAP for the rest of the varieties [6,8]. The resistance of the clone KIS 94-1/5-14 was tested at the Potato research Institute in Havličkův Brod, Czech Republic [2]. The plot size was 20 plants with planting density of 4,7 plants per m^2. The plots contained two rows, 70 cm wide and 3 m long. The seed tubers were planted 30 cm apart in the rows. Extra rows were included and planted as guard rows and spray ways. Weed, aphid and blight control were applied according to the local farm practice, as well as the fertilization rates.

At the end of the season (in September), tubers were hand dug. They were graded in two grades: large tubers with tuber size over 5 cm (marketable yield) and small tubers which were smaller than 5 cm. Total yield and total number of tubers, the yield and number of tubers of each grade and the ratio between them were determined.

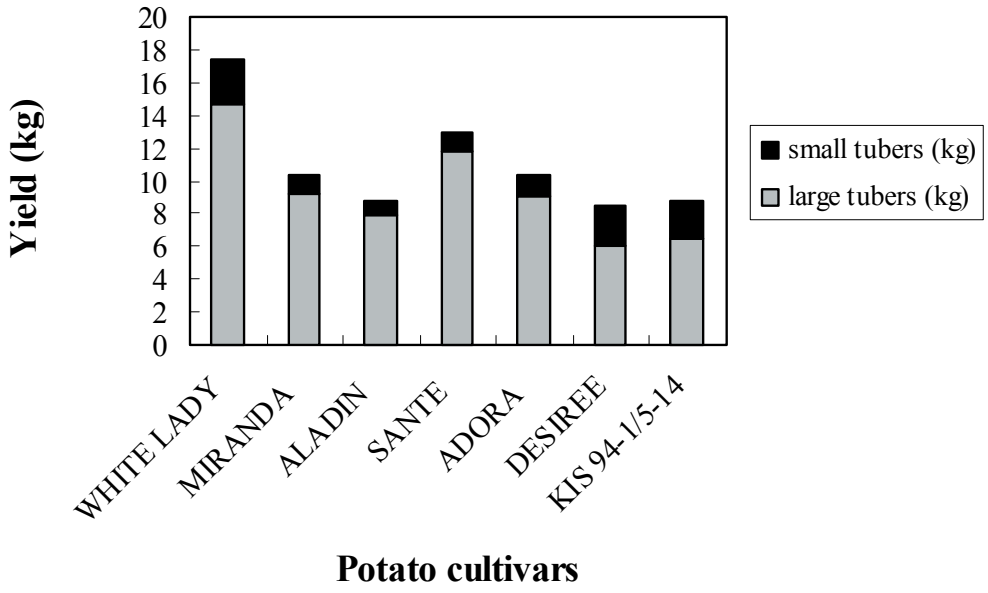
The population size of G. rostochiensis in the soil was assessed at planting (Pi) and after harvest (Pf) by taking a soil sample of c. 250 g (made up of 30 cores (1,4/10 cm) from each plot. The samples were air dried in the laboratory, then further dried for 24 hours in a dryer at 35°C. Cysts were extracted by sieving through a 250 μm sieve and an improved ARS-USDA washing device [5]. The viability of G. rostochiensis cysts extracted from each soil sample was examined. The cysts from each soil sample were smashed and juveniles and viable eggs separated and counted using a binocular microscope.

3. RESULTS

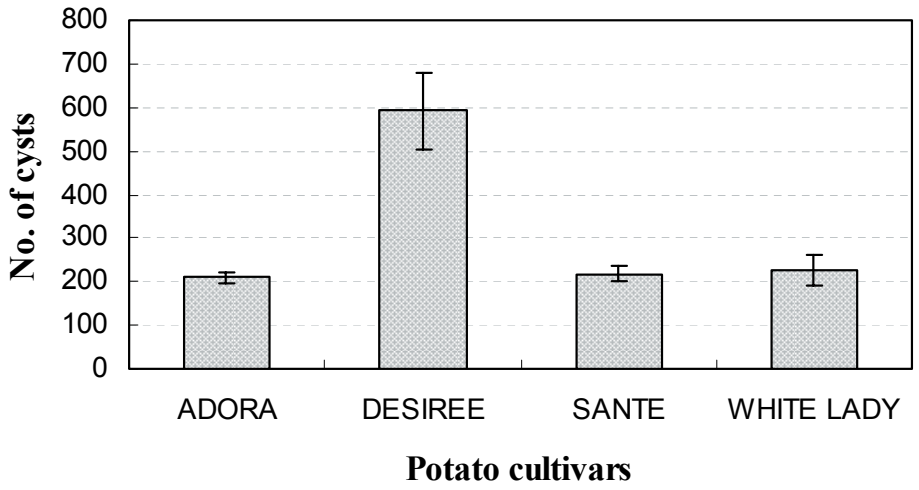
The influence of G. rostochiensis on the yield of different potato cultivars was studied. The potato yield in different potato cultivars is presented in the Graph 1. Significant differences were detected in total tuber yields. Cv. White Lady had significantly higher yield than other cultivars. It was 17,47 kg/plot, the ratio of large to small tubers (RLST %) was 83,6:16,4 and was higher than that of cv. Sante (12,9 kg; RLST % = 90,5:9,5), Miranda (10,32 kg; RLST % = 89:11), Adora (10,29 kg; RLST % = 88,3:11,7) and Aladin (8,84 kg; RLST % = 87,2:12,8). Total tuber yields for the cultivars (the clone KIS 94-1/5-14 (8,74 kg; RLST % = 74,1:25,9) and cv. Desiree (8,51 kg/plot; RLST % = 68,4:31,6) were statistically different from that of cv. White lady, Sante, Miranda and Adora but not from cv. Aladin.

The total number of tubers was the greatest in cv. White Lady (221: 131 large and 91 small tubers) followed by Desiree (145: 56 + 89) which differed significantly from the former but not from the clone KIS 94-1/5-14 (136: 66 + 70) and Sante (129: 93 + 36). Sante was followed by Adora (102: 64 + 38), Miranda (100: 65 + 35) and Aladin (97: 62 + 35) which did not significantly differ between themselves but they differed from others.

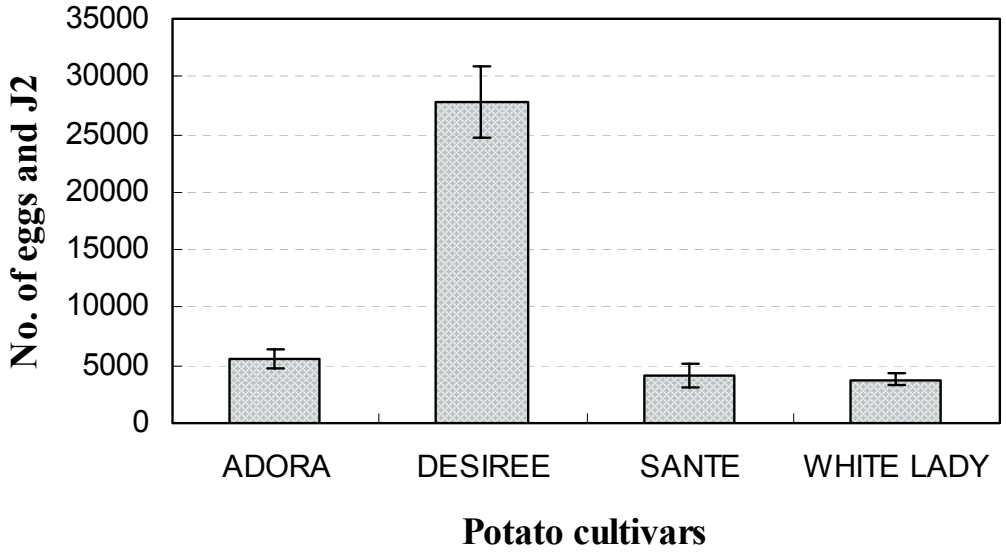
The population density of G. rostochiensis influenced by some resistant cultivars (White Lady, Sante, Adora) and the susceptible cultivar Desiree was determined after the growing season (Graph 2). The initial population of G. rostochiensis cysts / 100 cm^3 soil sample increased with the growth of the susceptible cv. Desiree by 2,8 times.



Graph 1: Potato yield in different potato cultivars



Graph 2: Total number of cysts of G. rostochiensis / 100 cm3 soil sample (Pi = 208 ± 50)



Graph 3: Total number of eggs and J2 of G. rostochiensis / 100 cm3 soil sample (Pi = 7013 ± 2340)

No population density growth of G. rostochiensis was observed with the resistant cultivars studied; the final populations (Pf) did not differ significantly from the initial populations (Pi).

Beside the number of cysts, the total number of viable eggs and J2 larvae / 100 cm^3 soil sample was determined (Graph 3). While the average number of viable eggs and J2 larvae in the susceptible cv. Desiree rose significantly from the initial 7.013 ± 2340 to the final 27.786 ± 6.118 (Pf/Pi = 3,96), the Pf/Pi value in the resistant cultivars used in the experiment (White lady: Pf/Pi = 0,54; Sante: Pf/Pi = 0,59; Adora: Pf/Pi = 0,79) decreased.

4. DISCUSSION

The economic damage caused by G. pallida and G. rostochiensis can be severe. If left uncontrolled, these nematodes can cause up to 80% yield loss [1]. Light infestations can reduce the tuber size whereas heavy infestations reduce both the number and the size of tubers. Increasing restrictions on the application of nematicides and fumigants will necessitate the use of alternative methods of nematode control such as long crop rotations, catch crops and the use of resistant cultivars [3].

Within Slovenia, the control of potato cyst nematodes is legislated by the restriction of seed production on infested land. It is also required to grow potato in at least four year crop rotation on infested land where ware potato is produced. In the areas where potato is produced mainly as monoculture it is recommended to grow resistant potato cultivars. The most effective way of reducing potato cyst nematode populations in infested soil is either to eliminate potato from crop rotation or to plant resistant potato cultivars.

While G. pallida has never been isolated from the arable soil in Slovenia, G. rostochiensis is a serious constraint on the production of potatoes by small-holder farmers, especially in the Trenta valley. Therefore, we tried to find out the way of sustainable potato production acceptable for people in that region where available arable land is very limited. Nematode resistant potatoes would reduce the pressure on cultivated land and significantly improve farmers' livelihoods.

So far, only one type of G. rostochiensis has been discovered in Slovenia (pathotype Ro1/4). Therefore the influence of this G. rostochiensis pathotype on the yield of different potato cultivars was studied. Our experiment confirmed several previous reports [7] that G. rostochiensis can directly reduce the yield of the susceptible potato cultivar Desiree and that the resistant cultivar White Lady is the most tolerant to nematode infection in Posočje (Trenta valley) where climate conditions are very specific for potato production. G. rostochiensis did not influence only the yield but also the average tuber size which is considered as one of the factors for tuber quality. Significant differences were

detected between the cultivars tested. The cultivar White Lady gave the best results and it appears to be the most suitable for growing in the Trenta valley. It produced good-quality tubers of acceptable size in a relatively short season. Late cvs. White Lady and Sante and early cv. Adora were found suitable for growing in the Trenta valley. All the other cultivars, especially the clone KIS 94-1/5-14 and cv. Desiree, gave smaller yields.

The influence of resistant potato cultivars on the population density and viability of G. rostochiensis was studied on cultivars (White Lady, Sante, Adora) resistant to G. rostochiensis pathotype Ro1/4 and on susceptible cultivar Desiree which was used as a control. Over a growing season, the G. rostochiensis population density increased to 396 % of the initial population in the plots where cultivar Desiree was grown. The G. rostochiensis population density decreased to 54 %, 59% and 79% after one year of growing the cultivars resistant to pathotype Ro1/4: White Lady, Sante and Adora, respectively. These data suggest that growing of resistant potato cultivars in infested areas could present an effective PCN management strategy.

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