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INFECTION OF POTATO TUBERS OF CHOSEN CULTIVARS BY Y, M, S AND POTATO LEAFROLL VIRUSES IN ECOLOGICAL CROPS IN THE NORTH OF POLAND IN YEARS 2006–2008

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Abstract

The threat of PVY, PVM, PVS and PLRV infection for potato cultivars including seven "old" (cultivars already removed from the Polish Central Cultivar Registry) and seven "new" cultivars (registered in the Polish Central Cultivar Registry) was estimated under field conditions in three ecological farms placed in northern Poland in 2006–2008. After three-year-long reproduction the infection rate of the most important virus – PVY for "old" cultivars was high (average 58–100% for cultivars 'Orzeł' and 'Epoka', respectively). This result is in agreement with their low resistance to the virus. Therefore these "old" cultivars are not suitable for ecological farming without frequent exchange of seed material. In turn, some "new" cultivars ('Korona', 'Bartek') had high resistance to PVY and practically were not infected under the same conditions. These cultivars can be recommended for ecological farming without risk of quick degeneration of tubers. To test if there is a need of frequent seed material exchange of the "new" cultivars, one season experiment was set in 2008. The produced tubers were almost free from infection and met seed material standards, except for cv. 'Justa' (infection rate 12%). During the investigated period infection with PLRV was not observed in any of the tested cultivars.

Key words: potato, viruses, infection, ecological crops

Introduction

Potato is a difficult plant in cultivation as an ecological crop, because it is threatened by different pests. The most important of those are weeds, some fungal

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and bacterial pathogens and among insects – Colorado beetle (*Leptinotarsa decemlineata*) is the most relevant in terms of economy in this system of cultivation. Virus infections constitute the greatest threat in potato seed production as they are major cause of seed potatoes bad quality. In accordance with the abiding rules, the seed material that is used ought to be ecological. Only in the case of its absence, one can occasionally admit the usage of seeds from conventional agriculture farms (after having obtained the permission of an ecological counsellor from the certifying unit).

At present there are 38 viruses that are likely to infect potatoes. In Poland four of those are commonly present: *Potato virus Y* (PVY), *Potato virus M* (PVM), *Potato virus S* (PVS) and *Potato leafroll virus* (PLRV). There is no doubt that PVY constitutes the greatest threat as it infects potatoes in all regions all over the world (de Boks and Huttinga 1981, Barnett 1992, Burrows and Zitter 2005).

PVM and PVS are considered less threatening. Both are common and spread easily which is favoured by high susceptibility of the cropped potato cultivars. In Poland, PVM isolates which evoke weak disease symptoms on plants dominate. But the significance of the virus can be enormous in the case of particularly susceptible cultivars. There are examples when some potato cultivars may react very strongly to infection with PVM and in accordance with the abiding seed production rules, strong disease symptoms are qualified as acute illness and constitute the basis for disqualification of entire seed plantations.

PVS does not have great significance in the large scale potato production (Brunt 2001). However, since it is common, it may also be troublesome in seed production of the plant. Commonly, the infected plants are symptomless or the symptoms are hardly noticeable and only an experienced observer is capable of differentiating between infected and the healthy plants.

The basic technology in seed potato production by ecological and conventional methods is similar. The most crucial differences concern restrictions in some fertilizers and plant protection treatments in ecological production. Conditions under which potato seed material can be produced are contained in the Bill on Seed Production from 26 June 2003 (National Bills Register dated 6 August 2003) and many executive regulations of the Ministry of Agriculture and Rural Development in Poland accompanying this bill.

Potato cultivars differ with respect to resistance to viruses. Therefore, their proper selection depending on the conditions in which seed material is to be produced is of crucial importance to seed potato producers. The results of many years of research have clearly shown that in Poland the following three factors have the greatest influence on potato virus infection: cultivar resistance, place of reproduction (zone of virus infection pressure) and agro-technological measures. Gabriel (1965) differentiated four zones of potato degeneration due to PVY and PLRV, at present referred to as PVY and PLRV pressure zones (Gabriel 1986). The most favourable conditions for seed production occur in zone 1 – the entire northern belt of the country, with the lowest pressure in north-eastern part of Poland. The greatest threat of these viruses infection is found in the fourth zone – mostly in the south-western part of the country. In ecological farming the production of seeds of cultivars with the shortest growth season is more dependable. Healthy material is

needed to set up plantations. The cultivars for particular regions, should be chosen so, that in regions with a higher infection threat seed production of cultivars susceptible to viruses (i.e. degree "6" or less in a 9-grade-scale, with "9" meaning extreme resistance) should be excluded, due to the risk of a high degree virus infection, leading to disqualification of the seed plantation. It is assumed that in zones 1 and 2, the production of all the potato cultivars registered in Poland is possible. However, only cultivars with grade "7" or higher should be chosen for reproduction in pressure zones 3 and 4 (Zarzyńska and Goliszewski 2007).

The aim of the work was to assess the threat by PVY, PVM, PVS and PLRV to potato crops in the North of Poland, having in view ecological production.

Material and methods

The experiments were carried out in the field, in three ecological farms in the north of Poland: Cewlino, Rekowo and Świdwin (Western Pomerania region). All the farms had appropriate certificates confirming that they were entitled to produce plants and seeds by an ecological method.

Fourteen potato cultivars with differentiated resistance to viruses were thus taken into account (Table 1).

Table 1

Resistance of potato cultivars to PVY and PLRV

Cultivar	PVY	PLRV
"Old"		
'Lipiński Wczesny'	Fairly resistant (5)	Moderately resistant (5)
'Dalia'	Moderately resistant (5)	Moderately resistant (5)
'Giewont'	Moderately resistant (5)	Susceptible (3)
'Orzeł'	Fairly resistant (6)	Very susceptible (2)
'Epoka'	Average susceptible (4)	Susceptible (3)
'Wyszoborski'	Moderately resistant (5)	Moderately resistant (5)
'Pola'	Resistant (7)	Moderately resistant (5)
"New"*		
'Miłek'	7	5–6
'Denar'	7	7
'Irys'	5.5	4
'Korona'	8	6.5
'Bartek'	8	8
'Czapla'	7	5
'Justa'	5–6	5-6

*The resistance is expressed as the scale from "1" to "9", where "1" means the very high susceptibility, and "9" the extreme resistance.

For experiment, the aim of which was to assess tuber infection with PVY, PVM, PVS and PLRV after their three-year-long reproduction, eight cultivars were used, out of which four were the "old" cultivars ('Dalia', 'Orzeł', 'Epoka' and 'Wyszoborski') removed of the Polish Central Cultivar Registry many years ago, and the remaining four ('Denar', 'Irys', 'Korona' and 'Bartek') are currently found in the registry. The choice of the "old" cultivars resulted from the fact that they are often looked for by many smaller producers as they had been remembered as valuable in terms of taste and crops.

Perfectly healthy potato tubers taken from *in vitro* cultures constituted the base material in the first year of research (reproduction). In the two following years offspring tubers were used. Each time 100 tubers of a given cultivar were planted. During vegetation season there were two chemical treatments: against Colorado beetle (Novodor 02 S.C., 5 kg/ha) and against late blight of potato (*Phytophthora infestans*; Miedzian 50 WG, 5 kg/ha).

After the growing season finished (after the third year of the reproduction), the tubers were collected from 15 plants of the middle part of the field for diagnosis for presence of PVY, PVM, PVS or PLRV. The tubers were stored until the following spring in a storage in temperature ranging from 4° to 6°C and relative humidity ca 90% in most cases.

In May eye-fragments were cut out from 50 tubers of each cultivar and planted in a glasshouse in pots filled with peat. After about six weeks two leaves were collected from each plant middle belt and juice was squeezed out for diagnostic research in an ELISA test, with antibodies from Bioreba.

Results

In Table 2 the results concerning infection of the eight potato cultivars with PVY, PVM, PVS and PLRV after a three-year-long reproduction in the location of Cewlino are presented (four "old" cultivars and four "new" cultivars). In relation to the "old" cultivars, it was the PVY that constituted the greatest threat. Average infection of tubers was very high, amounting 87.5% (from 58% in cv. 'Orzeł' to 100% in cv. 'Epoka').

Average infection of tubers with PVM was 17%. The infection of tubers ranged from 8% (cv. 'Dalia' cultivar) to 36% (cv. 'Orzeł').

PVS spread more intensely than PVM: most infected tubers were recorded in the 'Wyszoborski' cultivar (78%) and least in the 'Dalia' cultivar (18%). One has to highlight that none of the cultivars was infected with PLRV. This most probably means that in the course of research conditions for the virus spread were not favourable.

With reference to infection of "new" cultivars' tubers with PVY, 'Bartek' cultivar was not infected at all, and 'Korona' cultivar – only to a very small extent (2%). The highest PVY infection level was recorded for 'Irys' cultivar (62%), and much lower for 'Denar' cultivar (24%).

Table 2

Share of tubers infected with PVY, PVM, PVS and PLRV after three-year-long reproduction (2006–2008) in Cewlino (%)

Cultivar	PVY	PVM	PVS	PLRV
"Old"				
'Dalia'	94	8	18	0
'Orzeł'	58	36	34	0
'Epoka'	100	12	34.7	0
'Wyszoborski'	98	12	78	0
Mean	87.5	17.0	41.2	0
"New"				
'Denar'	24	16	2	0
'Irys'	62	12	86	0
'Korona'	2	2	22	0
'Bartek'	0	2	76	0
Mean	22	8	46.5	0

The highest PVM infection was registered for cultivars 'Denar' and 'Irys', 16 and 12% respectively. The virus constituted a serious threat with PVS, especially for cultivars 'Irys' and 'Bartek' which had a very high percentage of infected tubers, 86 and 76% respectively. Also in the "new" cultivars, PLRV did not constitute any threat, as no tubers were infected.

Table 3 presents the results of eight potato cultivar tubers infection with PVY, PVM, PVS and PLRV after a one-year-long reproduction in 2008, in three locations. Three "new" and five "old" cultivars were taken into account. Tuber infection with PVY and PVM viruses was usually low while some cultivars were not infected at all. The highest percentage of these virus-infected tubers was recorded in 'Justa' cultivar ("new" cultivar) in Cewlino (12% and 16%, respectively). In the two remaining locations (Rekowo and Świdwin) PVY and PVM infection was also low and did not exceed 4% and 2% respectively, in all cultivars. Similarly, PVS did not constitute a great threat – tubers were infected only in some cultivars (up to 8% in cultivars 'Justa' and 'Miłek' in the location of Rekowo). Slight level of PLRV infection (2% of infected tubers in cvs. 'Czapla' and 'Miłek') was observed only in the location of Rekowo, in which PVS constituted the greatest threat for the "old" cultivars (differences between the cultivars ranged from 8% in the cv. 'Lipiński Wczesny' to 39% in cv. 'Pola'). Certain threat in the location of Cewlino was constituted with PVM for "old" cultivars (from 2% in cv. 'Giewont' to 16% in cv. 'Wyszoborski') and "new" cultivars (from 8% in cvs. 'Czapla' and 'Miłek' to 16% in cv. 'Justa').

Table 3

Share of tubers infected with PVY, PVM, PVS and PLRV after one-year-long reproduction (2008) in three localities (%)

Cultivar	Cewlino				Rekowo				Świdwin			
	PVY	PVM	PVS	PLRV	PVY	PVM	PVS	PLRV	PVY	PVM	PVS	PLRV
"Old"												
'Orzeł'	0	8	0	0	0	2	10	0	6	0	0	0
'Pola'	0	14	24	0	0	0	39	0	0	0	0	0
'Giewont'	0	2	0	0	0	8	18	0	2	0	0	0
'Lipiński Wczesny'	2	4	0	0	2	2	8	0	0	0	0	2
'Wyszoborski'	6	16	0	0	0	2	12	4	4	12	0	0
"New"												
'Czapla'*	4	8	4	0	2	0	0	2	4	0	0	0
'Justa'	12	16	0	0	0	2	8	0	0	2	0	0
'Miłek'	4	8	4	0	0	2	8	2	0	0	0	0

*Removed in 2009.

Discussion

PVY is at present the most important virus affecting potato crops in Poland. The results of "old" cultivar tubers infection by the pathogen in ecological farms in the process of three-year-long reproduction showed that their reproduction was economically very risky. This is confirmed by the high level of tuber infection of all these cultivars, ranging from 58% in cv. 'Orzeł' to 100% in cv. 'Epoka', which results from low resistance of these cultivars especially to PVY (Table 1; Komorowska-Jędrys et al. 1999, Stypa 2006, Lista... 2009). PVS constitutes a relatively smaller threat, while PVM – still smaller, so that both these viruses do not cause a large decrease in crop of tubers and, thus, they are not as economically relevant as PVY. A lack of PLRV infection threat in Poland is a positive conclusion resulting of this studies. The pathogen was widespread in Poland, especially during 1970ties and from the economic point of view it was comparable with PVY.

The data in Table 2 show that PVY infection of some of the "new" cultivars ('Korona', 'Bartek') was practically not registered. These cultivars represent a group of cultivars highly resistant to PVY ("8" in a 9-grade scale). In the chosen group of cultivars 'Irys' is the most susceptible to PVY, as its resistance degree is "5.5", hence, a very high level of tuber infection (62%). 'Denar' is much more resistant, with "7" grade, and therefore the percentage of infected tubers was lower (24%). A relatively high level of PVM and PVS infection results from the fact that the resistance of a definitely great majority of cultivars to these two pathogens is not high. PLRV infection was not recorded either.

The potato cultivars resistant to PVY, e.g. 'Korona' and 'Bartek', are perfectly suitable for cultivation in an ecological system, with no fear that within three years of reproduction they will degenerate. Cultivation of crops of low resistance demands frequent qualified seed material renovation, so that proper material would not be reproduced too long. The frequency of exchange should depend on the degree of cultivar resistance, to PVY in particular, as well of course as on the region of crop production.

The above results confirm previous data (Kostiw 2002, 2004 a, b) informing of a very low threat of the potato leafroll virus to potato crops. Tuber infection by the pathogen was scarce even in cultivars which were highly susceptible to PLRV. So far, the reason of the situation has not been found, but it is believed that one of the causes is potato crop area decrease in Poland (about five times), the result of which is a smaller number of virus sources in the field and an increased spatial isolation between plantations, which hampers the flight of aphids (virus vectors) from outside (Kostiw 2004 a, b).

The choice of cultivars resistant to PVY and PLRV, optimum in the degree "7" or higher, is crucial for seed production of potatoes in the ecological system.

Streszczenie

PORAŻENIE BULW WYBRANYCH ODMIAN ZIEMNIAKA WIRUSAMI Y, M, S I LIŚCIOZWOJU ZIEMNIAKA W UPRAWIE EKOLOGICZNEJ NA PÓŁNOCY POLSKI W LATACH 2006–2008

W trzech gospodarstwach ekologicznych położonych na północy Polski porównano w latach 2006–2008 w warunkach polowych porażenie bulw ziemniaka przez PVY, PVM, PVS i PLRV siedmiu odmian „starych", dawno skreślonych z Krajowego Rejestru Odmian, i siedmiu odmian „nowych", znajdujących się w rejestrze. Badania diagnostyczne wirusów przeprowadzono z zastosowaniem testu ELISA. Największe zagrożenie stanowił bardzo groźny w produkcji ziemniaka wirus PVY. W wyniku trzyletniej reprodukcji czterech odmian „starych" ('Dalia', 'Orzeł', 'Epoka', 'Wyszoborski') porażenie bulw tym patogenem było bardzo duże: od 58% (odm. 'Orzeł') do 100% (odm. 'Epoka'). Mniejsze zagrożenie stwarzał wirus PVS (18–78%, zależnie od odmiany), a jeszcze mniejsze – PVM (8–36%). W latach badań wirus PLRV nie stanowił żadnego zagrożenia.

Bardzo duże porażenie badanych odmian przez wirus PVY sprawia, że ich produkcja metodami ekologicznymi może być prowadzona wyłącznie pod warunkiem częstej wymiany materiału nasiennego.

Spośród czterech odmian „nowych" najlepsze okazały się odmiany 'Bartek' i 'Korona'. Ich bulwy praktycznie nie były porażane przez PVY ani PVM i nadają się do produkcji ekologicznej. Większe porażenie tymi patogenami stwierdzono u odmiany 'Denar' (odpowiednio 24% i 16%). Z kolei bulwy odmiany 'Irys' były bardzo mocno porażone przez wirusy PVS (86%) i PVY (62%). Duże zagrożenie, szczegól-

nie przez PVY, jest dowodem, że produkcja tej odmiany w gospodarstwach ekologicznych wymaga częstej wymiany sadzeniaków.

Po jednorocznej reprodukcji w 2008 roku pięciu odmian „starych" i trzech „nowych" w trzech miejscowościach nie stwierdzono dużego porażenia bulw przez PVY, co świadczy o tym, że wytworzony w tym roku we własnym gospodarstwie materiał mógł być stosowany jako materiał nasienny w następnym roku bez konieczności jego wymiany. Porażenie odmian „starych" wynosiło od zera do 6%, niezależnie od miejscowości i odmiany. Z odmian „nowych" jedynie 'Justa' uległa porażeniu większemu (12%) niż dwie pozostałe odmiany ('Czapla' i 'Miłek' – po 4% porażenia).

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