



Preliminary Screening Some Potato Cultivars for Resistance to Potato Wart in Georgia

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A B S T R A C T

Potato wart (*Synchytrium endobioticum*) is a very important quarantine disease worldwide. The disease was first found in Georgia in 2009. Because of the unreliable chemical control to eliminate the pest in the soil, it is applicable to cultivate potato varieties resistant to the pathotypes present in the infested plots. To prevent the disease spread, it is very important to test imported potatoes for the resistance to the disease before commercially releasing them in fields. The preliminary assessment of introduced commercial potato cultivars for resistance to potato wart in infested plots was carried out using the field test in Skvana and Uchkho villages, and the pot test for Didajara village in Khulo municipality. As a result of screening, potato cultivars showed the different reactions to potato wart in field and pot tests. The majority of the tested cultivars were susceptible to the wart and only several cultivars showed resistance in separate tests.

Keywords: Potato varieties, Potato wart, Resistance, *Synchytrium endobioticum*, Screening, Pathogen.

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Introduction

The main parts of potato plantations are located in mountainous areas of Western and Southern Georgia. According to the data of GeoStat (2017), the average yield of potato is still low and ranges from 8 to 11 t/ha [1]. One of the important limiting factor in potato production in Georgia is potato wart caused by the obligate biotrophic, soil-borne fungal pathogen *Synchytrium endobioticum* (Schilb.) Perc. [2, 3].

The pathogen included on A2 quarantine list of EPPO occurs locally in almost all countries in the EPPO region [4, 5], including Georgia where it was first found in Didajara and Tabakhmela villages of Khulo municipality in 2009. In 2010-2012, the disease was found in other villages in Khulo on varieties Agria, Finka, Picasso and Marfona [6]. Later, disease foci were also found in various private plots in Mestia municipalities in the region of Samegrelo-Zemo Svaneti [7]

Potato wart (PW) is a very harmful disease [8]. The diseased tubers are unmarketable because of proliferating warts on potato tubers, formed during the growing season that may continue developing after harvest [9]. The resting spores of the causative agent survive in soils and can be infectious for 20-50 years [10]. Therefore, infested plots cannot be used for potato production for more than 20 years after the detection of the pest [11]. Yield losses may vary between 50-100 % under conditions favorable to disease development [12].

Furthermore, the fungus develops new pathotypes that are a serious threat to disease control because a new race can infect already existing resistant potato varieties to PW. Today, more than 40 pathotypes of the pathogen have been known [13-15]. Among them, the pathotypes 1(D1), 2(G1), 6(O1), 8(F1) and 18(T1) are the most important

in Europe [16]. As the results of the collaborative work between labs in Georgia and the Netherlands for the determination of pathotypes present in Georgia conducted in 2013-2017 years, the presence of pathotype 38 (Nevşehir) in Didajara village of Khulo municipality was reported [17], which is expected to spread in Georgia from Turkey while exporting potato crops.

Because of the elimination of the pest in the soil is impossible through chemical control, the only available strategy to prevent further spread of the disease is to apply strict phytosanitary measures combined with the cultivation of potato varieties resistant to the pathotypes present in the infested fields [18].

As potato producers in Georgia do not practice the local selection and seed production, potatoes are imported from Armenia, Turkey, Germany, Iran, the Netherlands, and other countries. Some potato cultivars Marfona, Picasso, Agria, Finka, Impala introduced in Georgia in 90th years of the previous century are growing despite their susceptibility to the wart. To prevent the disease spread, it is very important to test imported potatoes for the resistance to PW before planting them in the field.

This paper presents the results of the preliminary assessment of introduced potato cultivars for resistance to potato wart. The purpose of this study is to reveal the resistant varieties to wart in Khulo conditions and by that to meet the requirements of technical regulation for potato wart control accepted by the Georgian government in 2015 to prevent its spread in Georgia [19].

Material and methods

The potato cultivars grown in Georgia and some new cultivars were assessed for the reaction to PW using pot and field tests.

Pot test. Pot trials were conducted in 2016. Samples of soil (with density of 22 winter sporangia per g soil) originated from infested fields located in village Didajara, Khulo mountain region were placed in pots (5 L) and 37 introduced cultivars (Pekaro, Spunta, Jelly, Nandina, Panamera, Omega, Artemis, Figaro, Bernadette, Europrima, Marfona, Marabel, Estela, Alwara, Agria, Saturna, Sylvana, Glorietta, Impala, Laura, Arnova, Sofia, Annalena, Arizona, Fabula, Caruso, Finka, Arinda, Milva, Sante, Meskhuri tsiteli, Javakheturi, Meskhuri, Briz, Skrab, Uladar, Lileya) were planted. Each pot contained 2-3 tubers and three replications per cultivars were used.

Cultivar Marfona served as positive control. The pots were placed in a glasshouse at the end of autumn with supplementary lighting and handy washing to keep suitable soil moisture. The temperature and the relative humidity in glasshouse varied between approximately 18-20°C and 70-85%, respectively. When tubers formed, plants were removed from pots, and wart development was evaluated for the stem base, stolons and tubers. Wart symptoms were assessed by the Spieckermann scale [20].

Field test. In 2017-2018, field tests were conducted in Skvana and Uchkho villages of Khulo municipality. Before planting potato cultivars, the soil samples were collected from the infested foci and examined for the presence of the resting sporangia of *S. endobioticum* under a microscope. The density of sporangia per gram of soil was also determined (EPPO, 2004). As a result of a direct examination, 12 sporangia per g soil were revealed in the infested soil of Skvana village and 8 sporangia in the soil of Uchkho village.

Tubers were planted at a distance of 70 X 30 cm. 5-10 tubers per tested cultivar were planted by hand. The number of tubers planted in the fields was depended on the number of seed potatoes available. By the end of growing season, the tubers were harvested by hand and the wart development was evaluated. When a single wart with winter sporangia was formed, the cultivar was rated as susceptible. When no such reaction has occurred, the cultivar was rated as resistant. The disease severity in the fields was evaluated for each plant separately according to the number and the size of warts using the scale specified in the EPPO Diagnostic Protocol (EPPO, 2004).

In 2017, the field test in the infested private plot was conducted at an altitude of 1291 m above sea level (N41*32.875, E04*29.098) in Skvana village where average air temperature was ~ 8°C, humidity 70-80%. The cultivars Marfona, Marabel, Briz, Lileya, Uladar, Agria, Impala, Laura, Saturna, Sylvana, Glorietta, Meskhuri, Javakheturi, Skrab, Estela, Alwara were planted on early May and harvested on early September.

In 2018, the field test in the infested private plot was carried out at an altitude of 1083 m above sea level (N41.40.969, E042.18513) in Uchkho village (average air temperature ~ 12°C, humidity 85%). In Khulo the brown forest soils with low acidity have occurred. The cultivars Pekaro, Spunta, Red Fantasy, El mundo, Leandra, Andrea, Catania, Jelly, Florente, Carlita, Captiva, Cardinia, Coronada, Nandina, Pan-

amara, Magda, Artemis, Figaro, Bernadette, Europrima, Marfona, Marabel, Lileya, Agria, Saturna, Sylvana, Glorietta, Javakheturi, Meskhuri, Skrab, Briz, Uladar, Estela, Alwara were planted on early April and harvested in late July. After harvesting, each plant was evaluated separately according to the number and size of the warts using the scale (Table 1).

Results and discussion

Pot test. According to the results of the pot test (Table 1) from thirty-seven cultivars of potato tested for wart resistance the majority of the cultivars Nandina, Glorietta, Bernadette, Marfona, Pekaro, Panamera, Spunta, Annalena, Estela, Europrima, Sylvana, Finca, Laura, Figaro, Impala, Jelly, Alwara, Artemis, Milva, Agria, Sante Saturna, Briz, Lileya, Skrab, Uladar, Meskhuri tsiteli, Meskhuri and Javakheturi showed susceptible reaction. Among them, warts at the stem base were formed on cultivars: Nandina, Panamera, Annalena, Skrab,

Europrima, Sylvana, Finca, Impala and Sante. The cultivars Arnova, Sofia, Arizona, Fabula, Caruso, which are reported to be resistant to pathotype D1 of wart were also resistant in pot test, but the German cultivar Omega and the Dutch cultivar Arinda reacted as resistant in our experiment are characterized as susceptible to pathotype D1 in accordance with the catalogues [21,22]. This could be explained by the fact that pathotype 38 was identified in Didajara district (unpublished data) [17].

Field test. Sixteen and thirty-four cultivars were evaluated in the infested fields in Skvana village in 2017 and in Uchkho village in 2018, respectively. Cultivars that were available in those years were planted in the fields. The most of the cultivars (Marfona, Impala, Laura, Glorietta, Meskhuri, Javakheturi, Skrab, Estela, Alwara, Briz, Lileya, Uladar, Saturna,) tested in Skvana field were susceptible to the wart and only three cultivars Agria, Sylvana and Marabel showed resistance (Table 2).

Table 1. Reaction of potato cultivars to PW using pot test (Spieckermann scale) in 2016

N	Cultivars	Number of tuber eyes recorded	Number of diseased tubers	Resistant					Susceptible						Symptoms on other parts of	Overall	Reaction
				0	1	2	3	4	5								
				0	-	P	F	R	I	II	III	IV	V	X			
1	Marfona	24	14	10						4	2		4	3	1		S
2	Nandina	19	7	12							4	1	1	1		Wart at the stem bases – 4 cm	S
3	Glorietta	13	7	6					4			1		2			S
4	Bernadette	19	4	15					1			2	1	2			S
5	Arnova	11	0	11													R
6	Pekaro	39	14	10		15			7			2	3	2			S
7	Sofia	13		8		5											R
8	Agria	16	4	12													S
9	Spunta	22	7	9		6			3	2	1	1					S

10	Panamera	25	5	20					1	3	1			Warts at the stem bases – 2 - 3 cm	S
11	Artemis	12	4	8				2	1	1					S
12	Milva	11	7	4				2	1	1	1	1	1		S
13	Annalena	21	5	6	10				2	2	1			Warts at the stem bases – 1 cm;	S
14	Estela	18	5	13				1	2	2					S
15	Arizona	7	0	7											R
16	Marabel	15	4	15				2	1	1					S
17	Europrima	7	3	4					3					Warts at the stem bases – 2 cm;	S
18	Fabula	25	0	21	4										R
19	Caruso	13	0	0	13										R
20	Laura	7	2		5			1	1						S
21	Sylvana	12	2	8	2			2						Warts at the stem bases – 1.5 cm;	S
22	Omega	20	0		20										R
23	Finca	30	7		23			6	1					Warts at the stem bases – 3 cm;	S
24	Figaro	23	5	18				2	2	1					S
25	Arinda	11	0		11										R
26	Sante	22	6	16					1	2	2	1		Warts at the stem bases – 2,5 cm;	
27	Jelly	12	4	8				1	1	2					S
28	Impala	21	12	9				3	4	4		1		Warts at the stem bases 1.3– 2 cm;	S
29	Alwara	13	5		8			2	2	1					S
30	Saturna	20	6	12	2			2	1	2	1				S

31	Skrab	12	5	7					2	1	1	1			Warts at the stem bases – 4 cm;	S
32	Briz	18	8	4		6			2	2	3	1				S
33	Lileya	20	11	5		4			4	3	2	2				S
34	Uladar	17	6	11						2		3	1			S
35	Meskhuri Tsiteli	15	7	8						2	3	1	1			S
36	Meskhuri	18	6	10		2					3	2	1			S
37	Javakheturi	16	5	11						1	3	1				S

*0, no reaction visible; type –, or 1-early defence necrosis; type 2 or P- late defence necrosis; type 3 or F, very late defence necrosis; type 4 or R, weakly susceptible, type 5 or susceptible (wart types I, II, III, IV, V, and X): I (2–3 mm diam), II (4–5 mm), III (6–7 mm), IV (8–10 mm), V (11–15 mm) and X (16–20 mm and bigger). S, susceptible reaction; R, resistant reaction.

However, wart proliferations were visible on the tubers of these cultivars in the field test con-

ducted in Uchkho and pot test with inoculum from Didajara village.

Table 2. The results of reaction types of potato cultivars to PW during the field test in the village of Skvana, 2017

N	Potato cultivars	Total number of tubers	Diseased	Rotten	Scale									Reaction Type	
					1 Class	2 Class	3 Class	4 Class	5 Class	6 Class	7 Class	8 Class	9 Class		
1	Marfona	24	7		17	2	3							2	3 (S)
2	Marabel	9			9										1 (R)
3	Briz	44	13		31	1	2		3	2	5				7 (S)
4	Lileya	76	23		53	7	3	5	5	1	1	1			2 (S)
5	Uladar	31	11		20		4	3	2	2					3 (S)
6	Agria	6			6										1 (R)
7	Impala	52	16		36	2	4	5	3	2					4 (S)
8	Laura	9	5		6		3	1	1						3 (S)
9	Saturna	71	19	1	52			3	4	6	1	2	1		6 (S)
10	Sylvana	69			69										1 (R)
11	Glorietta	23	9	16	14	2	3	1	2	1					3 (S)
12	Meskhuri	21	8	11	13	4	2	1	1						2 (S)
13	Skrab	26	9		17			5	2	1	1				4 (S)
14	Estela	32	11		21	2			4	2	2	1			5 (S)
15	Alwara	28	12		16		3	4	2	2	1				4 (S)
16	Javakheturi	20	8			3	2	2	1						2 (S)

Thirty- one cultivars (Europrima, Bernadette, Figaro, Magda, Panamera, Nandina, Coronada, Captiva, Carlita, Florente, Jelly, Andrea, El mundo, Red Fantasy, Pekaro, Estela, Marfona, Sylvana, Marabel, Agria, Artemis, Alwara, Spunta, Glorietta, Lileya, Saturna, Briz, Uladar, Scrab, Meskhuri

and Javakheturi planted in the field trial of Uchkho showed the susceptible reaction to potato wart. The remaining three cultivars Catania, Lendra and Cardinia which are reported to be resistant to D1 [23] were also resistant in Uchkho field trial (Table 3).

Table 3. The results of reaction types of potato cultivars to PW during the Field Test in the Village of Uchkho, 2018

N	Potato cultivars	Total number of tubers harvested	Diseased	Rotten	Scale									Reaction Type	
					1 Class	2 Class	3 Class	4 Class	5 Class	6 Class	7 Class	8 Class	9 Class		
1	Marfona	21	5		16	1			4						5 (S)
2	Sylvana	37	9	3	28	3	4	2							3 (S)
3	Marabel	13	7	1	5		7								3 (S)
4	Europrima	15	14		1	8		3			2	1			2 (S)
5	Bernadette	22	6	1	15	1	3				1		1		3 (S)
6	Figaro	40	10		30	3	4	1				1	1		3 (S)
7	Agria	15	4		11		2	1	1						3 (S)
8	Artemis	20	0		15	3	1								2 (S)
9	Spunta	5	3		2		2	1							3 (S)
10	Estela	44	14		30	7	1	3	3						2 (S)
11	Alwara	16	11		5	4	1	2	2			1	1		2 (S)
12	Glorietta	21	15		6	12	3								2 (S)
13	Magda	32	7		25		1	3	2	1					4 (S)
14	Panamera	10	4		5	1	2	1							3 (S)
15	Nandina	16	7		9	2	3	2							3 (S)
16	Coronada	8	8			8									2 (S)
17	Cardinia	39	0		39										1 (R)
18	Captiva	22	6	3	13	3	1	2							2 (S)
19	Carlita	29	15		14	3			2			6	4		8 (S)
20	Florente	47	11		36	3	2	1	1			4			8 (S)
21	Jelly	40	9		31	4	3	2							2 (S)
22	Catania	6			6										1 (R)
23	Andrea	26	5		20	3	2	1							2 (S)
24	Leandra	33			33										1 (R)
25	El mundo	32	7	1	24	3	2	2							2 (S)
26	Red Fantasy	17	4		13	2	1	1							2 (S)
27	Pekaro	71	15	15	56	8	5	2							2 (S)
28	Lileya	37	17	5	15	9	1			2	5				2 (S)
29	Skrab	39	39			18				2	15		4		2 (S)
30	Saturna	362	79	128	283	24	18	14	10	5		4	4		2 (S)
31	Briz	321	49		272	19	13	12	2	3					2 (S)
32	Uladar	69	24		45	11	5	4	2	2		1			2(S)
33	Javakheturi	23	18		5	7	6	1			1		3		2 (S)
34	Meskhuri	45	15		30	4	5	3	2	1					3 (S)

The results of all trials are summarized in Table 4. According to screening results, the main parts of evaluated cultivars (82.9%) were susceptible to wart in all trials. Based on a comparison of the results obtained in this study, the Belarusian cultivars Lileya, Briz, Uladar, Scrab, the Dutch cultivars Saturna, Marfona, Estela, Alwara and the cultivars Javakheturi and

Meskhuri selected from breeding materials of International Potato Center (CIP) were susceptible in the pot test as well as both field assays. However, we observe that some cultivars differed in their response to potato wart population with a different origin, so, they were resistant in one location but susceptible in another.

Table 4. Reaction of cultivars to PW using field and pot tests in Khulo Municipality

N	Cultivars	Pot Test	Disease rating in the field test (scale 1-9)*	
		Didajara (2016)	Skvana (2017)	Uchkho (2018)
1	Marfona	S	S	S
2	Sylvana	S	R	S
3	Marabel	S	R	S
4	Europrima	S	-	S
5	Bernadette	S	-	S
6	Figaro	S	-	S
7	Agria	S	R	S
8	Artemis	S	-	S
9	Skrab	S	S	S
10	Estela	S	S	S
11	Alwara	S	S	S
12	Omega	R	Missing	Missing
13	Glorietta	S	S	S
14	Magda	-	-	S
15	Panamera	S	-	S
16	Nandina	S	-	S
17	Coronada	-	-	S
18	Cardinia	-	-	R
19	Captiva	-	-	S
20	Carlita	-	-	S
21	Florente	-	-	S
22	Jelly	S	-	S
23	Sante	S	-	-
24	Catania	-	-	R
25	Andrea	-	-	S
26	Leandra	-	-	R
27	El mundo	-	-	S
28	Red Fantasy	-	-	S
29	Lileya	-	S	S
30	Spunta	S	-	R
31	Pekaro	S	-	S
32	Saturna	S	S	S
33	Briz	S	S	S
34	Uladar	S	S	S
35	Impala	S	S	-
36	Laura	S	S	-
37	Arnova	R	-	-
38	Sofia	R	-	-
39	Annalena	S	-	-
40	Arizona	R	-	-
41	Fabula	R	-	-
42	Caruso	R	-	-
43	Finca	S	-	-
44	Arinda	R	-	-
45	Milva	S	-	-
46	Javakheturi	S	-	S
47	Meskhuri	-	S	S
48	Meskhuri tsiteli	S	Missing	Missing

As above mentioned, the cultivars Agria, Sylvana and Marabel originating from the Netherlands reported to be resistant to potato wart, pathotype D1 [21], were also resistant in the field in Skvana village. However, they showed the susceptible reaction to wart (4 diseased tubers with 4 clones) in the field test conducted in Uchkho village and in the pot test.

In the study conducted in Turkey, the cultivars Marabel and Agria showed the susceptible reaction to the pathotype 38 (Nevşehir) of potato wart [24, 25]. Concerning the susceptible reaction of these cultivars to the wart, our results are like because the pathotype 38 was identified in the isolates originated from Didajara village. Different reaction of cultivars to wart population from Skvana can be explained that perhaps another pathotype is spread in the Skvana village. Pathotype identification of wart isolates from Skvana and Uchkho villages have not been carried out yet.

Conclusion

To the best of our knowledge, the current study presents the first data on the level of resistance among some introduced potato cultivars to wart using pot and field tests in the three locations of Khulo municipality.

Based on the results obtained in this study, most of the tested potato varieties currently being grown in Khulo should be withdrawn from commercial production due to their susceptible reaction to the wart. Several cultivars (Omega, Arnova, Sofia, Arizona, Fabula, Caruso, Arinda) showed resistance to the disease using pot test, the cultivars Catania, Leandra, and Cardinia were resistant in the field tests of Uchkho and the cultivars Sylvana, Marabel and Agria showed the resistance in Skvana field test. However, they cannot be recommended for growing in Khulo district because it is also necessary to assess the degree of resistance of these varieties using laboratory methods to confirm the results obtained in the future.

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