STRATEGIES OF REPRODUCTION AND OF VIABILITY SUPPORT OF OOMYCETE *PHYTOPHTHORAINFESTANS* IN IRAN

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Abstract: the paper describes living and infective cycles Phvtophthora infestans (Mont.) de Bary *in Iran Province Golestan. 3 255 blighted samples from potato and tomato leaflets were collected in 2009-2011 from private commercial fields (0.5-4 hectares) of seven locations. These samples represented 123 and 30 field P. infestans populations from potato and tomato respectively. The maximum means of disease frequency, disease severity, indexes of presence of zoosporangia and aggressiveness were registered for P. infestans field populations from potato and tomato not treated with fungicides. Especially aggressive were tomato populations from not local for Iran tomato cultivar Early Girl. On the contrary, low-leveled aforementioned features were obtained for potato populations of different origin treated with fungicides Equation pro and Ridomil Gold. All investigated P. infestans field populations were asexual with different levels of formation of zoosporangia. Weak and asexual strategies of reproduction were revealed. No oospores were revealed. This investigation has clearly demonstrated that in spite of current climate warming P. infestans still can be very dangerous pathogen which must be carefully monitored both in Iran and in Russia.*

Key words: Phvtophthora infestans, potato late blight, tomato late blight, Iran, Golestan, zoosporangia, strategies of reproduction, strategies of viability support.

Phvtophthora infestans (Mont.) de Bary is still very dangerous potato and tomato pathogen in spite of trend to climate warming [6]. This organism is well investigated in almost all regions of the world, but Iran is still an exception. Little is known about potato and tomato late blight in Iran. For example, influence of climatic conditions on late blight development was investigated [5, 7, 8].

Nothing is still known about specifics of living and infective cycles of *P. infestans* in Iran. It is rather ridiculous because potato affection in Iran can be very essential with strong lost of harvest, for example in Ardebil (1997), Golestan (2002, 2006) [5, 1]. Aim of the present investigation is providing true information about *P. infestans* living and infective cycles in Iran. For Iran, the obtained data are new and of urgent importance. For Russia, these data also can be very useful because of intensification of trade and economic interrelations between Russia and Iran. Thus, it is important to elucidate possible danger of Iran *P. infestans* populations for Southern regions of potato and tomato cropping in Russia, to estimate their potential of reproduction and viability under the field conditions.

Material and methods

In 2009-2011, 3 255 blighted samples from potato and tomato leaflets were collected from private commercial fields (0.5-4 hectares) of seven locations in Iran Province Golestan. These samples represented 123 and 30 field *P. infestans* populations from potato and tomato respectively (fig. 1, 2, table 1). Different potato and tomato cultivars were used

Fig. 1. Map of Iran. Province Golestan is yellow-marked

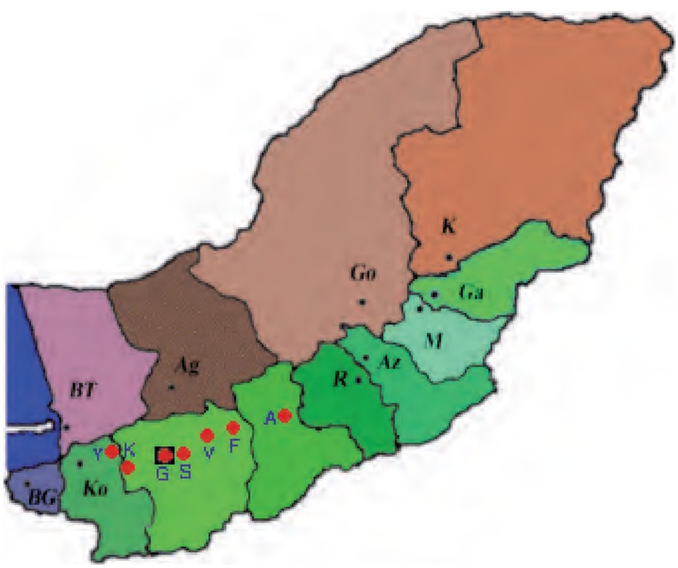

Fig. 2. Golestan province: abbreviation in map: **Az** Azadshahr **BT** Bandar-e Torkaman **K** Kalaleh **Go** Gonbad Kavoos **Ko** Kordkoov **Ga** GalikeshM Minoodasht **R** Ramivan **BG** Bandar-e Gaz **Ag** Aah Gha Y **Yassaghi-** K **Kafshgiri-** G **Goraan-** S **Sorkhan Kalate-** V **Valikabad-** F **Fazelabad-** A **Aliabad-e Katul** **Y** Yassaghi: 36° 49' 32" N, 54° 14' 28" E

Table 1

Geographic coordinates and altitude of investigated locations

Region	Geographic coordinates (GPS)		Altitude (m)
	North	East	
Y Yassaghi	36° 49' 32"	54° 14'28"	65
K Kafshgiri	36° 48' 36"	54° 17' 02"	85
G Gorgan	36° 50' 19"	54° 26' 5"	155
S Sorkhan Kalate	36° 52' 2"	54° 29' 7"	105
V Valikabad	36° 53' 29"	54° 34' 9"	51
F Fazelabad	36° 53' 54"	54° 44' 59"	186
A Aliabad-e Katul	36° 54' 30"	54° 52' 8"	140

in this investigation. Part of them were regularly treated with fungicides during vegetation season, other part of them was not treated. During field observation disease frequency (DF - per cent of blighted plants), disease severity (DS - per cent of necrotized leaf cover) were estimated).

After incubation in moist chambers (1 day), boiling ethanol (5 min) and 10% bleaching chlorine (2 hours), decolorized leaflets were checked for determination of *P. infestans* zoosporangia and oospores. Index of presence of zoosporangia **(IZ)** and oospores (IO) were calculated. Index of aggressiveness (IA) of field P. infestans populations was calculated as IA=(DFDSIZ)/10000 [2, 3].

Distribution of indexes IZ and 10 for asexual *P. infestans* populations gave an outline for two strategies of reproduction (SR): W (weak) with substrategy W1 (IZ=0.1-20.0), A (asexual): with substrategies A1 (IZ=20.1-40.0), A4 (IZ=40.1-60.0). A7 (IZ==60.1-100.0) [2, 3].

Maximum means of features DF, DS, IZ, IO, IA were 100%, minimum means were 0%.

Distribution of indexes IA and IO for asexual *P. in festans* populations gave an outline for two strategies of viability support (SVS): W (weak) with substrategy W1 (IA=0.1-10.0), A (aggressive): with substrategies A1 (IA=10.1-25.0), A4 (IA=25.1-50.0), A7 (IA==50.1-100.0) [2, 3].

LSD_{05} was determined by means of software STRAZ. *P. infestans* potato field population from Valikabad of 2009 was used as a control. Correlation analysis was performed by means of Microsoft EXCEL (2007), cluster analysis - by means of STATISCA 7.0.

Results and discussion

All field *P. infestans* populations manifested rather significant means of disease frequency, disease severity, index of presence of zoosporangia, index of aggressiveness (table 2). No oospores were detected.

The maximum features were registered for populations from potato and tomato not treated with fungicides. Especially aggressive were tomato populations from not local for Iran tomato cultivar Early Girl. On the contrary, low-leveled features were obtained for potato populations of different origin treated with fungicides Equation pro and Ridomil Gold (table 2).

Table 2

Disease frequency (DF), **disease severity** (DS), **index of formation of zoosporangia** (IZ), **index of aggressiveness** (IA) **for groups of potato and tomato field** *P. infestans* **populations**

Groups of *P. infestans* field populations					Features, %			
Year, host plant	Region	Cultivar	Fungicide	Number of tested popula-tions	DF	DS	IZ	IA
2009 Potato	Sorkhankalate	Sante	Equation pro	10	34.66	43.04	12.53	1.98
	Gorgan	Agria	Ridomil Gold	10	53.48	51.02	15.67	4.37
	Aliabad	Saxon	Mancozeb	10	53.61	62.31	23.74	7.94
	Valikabad	Marfona	No fungicides	10	70.51	76.96	35.87	19.56
	Fazelabad	Marfona	No fungicides	10	72.92	79.02	37.57	21.82
2009 Tomato	Kafshgiri	Early girl	No fungicides	13	60.30	70.31	98.11	41.60
	Yassaghi	Endemic	No fungicides	17	52.22	62.43	86.08	28.44
2010 Potato	Sorkhankalate	Draga	Equation pro	10	37.29	38.77	12.80	1.87
	Gorgan	Agria	Ridomil Gold	5	44.29	46.55	15.20	3.16
	Aliabad	Saxon	Copravit	5	53.54	59.99	20.88	6.76
	Valikabad	Marfona	No fungicides	5	63.49	66.81	30.66	13.24
	Fazelabad	Marfona	No fungicides	8	69.88	77.07	34.43	18.71
2011 Potato	Valikabad	Concord	Equation pro	15	19.06	18.64	6.10	0.29
	Fazelabad	Marfona	Equation pro	15	30.89	36.19	11.59	1.36
	Sorkhankalate	Sante	Equation pro	10	22.68	15.80	5.98	0.23
LSD_{05}					2.218	2.852	2.343	1.877

Correlation analysis indicated extremely high significant correlations between all investigated features (table 3). This contradicts to the results obtained for Moscow Region where the correlation level was essentially lower and can be explained as influence of extremely wet climate of area close to the Caspian Sea. Under conditions of the Moscow Region the continental climate influences the *P. infestans* field populations in a different other way.

Table 3

Means of correlation coefficients (right from diagonal for potato *P. infestans* **populations, left from diagonal for tomato** *P. infestans* **populations**

	IA	DF	DS	IZ
IA	–	0,903± 0,017	0,910 ± 0,015	0,975± 0,004
DF	0,976± 0,009	—	0,968± 0,006	0,945 ± 0,010
DS	0,990± 0,004	0,956 ± 0,016	—	0,962 ± 0,007
IZ	0,968± 0,012	0,906 ± 0,033	0,956± 0,016	—

All investigated *P. infestans* field populations were asexual with different levels of formation of zoosporangia. Weak and asexual strategies of reproduction were revealed (table 4). Cluster analysis on strategies of reproduction clearly indicated three kinds of *P. infestans* populations (fig. 3).

Table 4

Strategies of reproduction (SR) and viability support (SVS) for groups of potato and tomato field *P. infestans* populations

					Strategies			
					SR		SVS	
Year, Host plant	Region	Cultivar	Fungicide	Number of tested popula-tions	Type	%	Type	%
2009 Potato	Sorkhankalate	Sante	Equation pro	10	W1	100	W1	100
	Gorgan	Agria	Ridomil Gold	10	W1	100	W1	100
	Aliabad	Saxon	Mancozeb	10	W1 A1	20 80	W1	100
	Valikabad	Marfona	No fungicides	10	A1 A4	90 10	A1	100
	Fazelabad	Marfona	No fungicides	10	A1 A4	60 40	A1 A4	80 20
2009 Tomato	Kafshgiri	Early girl	No fungicides	13	A7	100	A4	100
	Yassaghi	Endemic	No fungicides	17	A7	100	A1 A4	41 59
2010 Potato	Sorkhankalate	Draga	Equation pro	10	W1	100	W1	100
	Gorgan	Agria	Ridomil Gold	5	W1	100	W1	100
	Aliabad	Saxon	Copravit	5	W1 A1	20 80	W1	100
	Valikabad	Marfona	No fungicides	5	A1	100	W1 A1	20 80
	Fazelabad	Marfona	No fungicides	8	A1 A4	75 25	A1	100
2011 Potato	Valikabad	Concord	Equation pro	15	W1	100	W1	100
	Fazelabad	Marfona	Equation pro	15	W1	100	W1	100
	Sorkhankalate	Sante	Equation pro	10	W1	100	W1	100

The first kind is characterized by the weak strategy and includes potato populations of different origin (year of collection, location and cultivar), but all of them were treated with fungicides Ridomil Gold or Equation pro.

The second kind is characterized by both weak substrategy W1 and asexual sub-strategies A1, A4 in different ratios. This kind includes potato populations of different origin (year of collection, location and cultivar) not treated with fungicides Ridomil Gold or

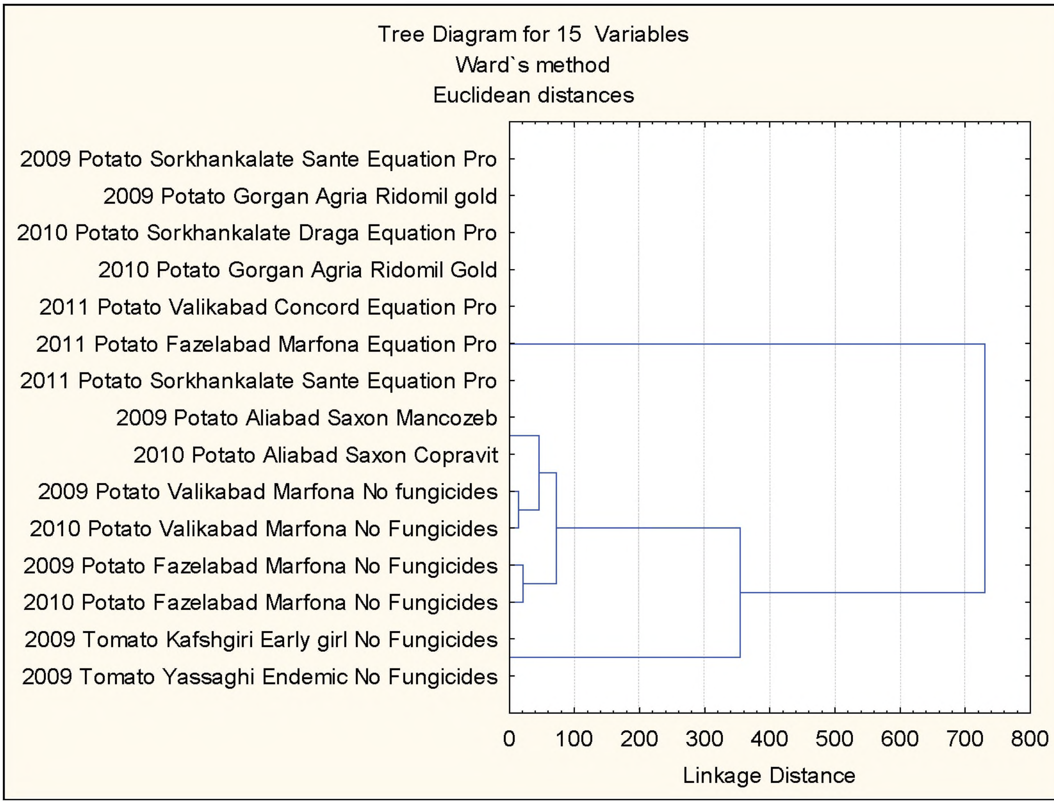

Fig. 3. Tree diagram for groups of potato and tomato field *P. infestans* populations according to their strategies of reproduction

Equation pro. At analysis of this group it is possible to distinguish subclaster with two groups of populations treated with Coprovit and Mancozeb.

The third kind is characterized by strong asexual substrategy A7 and includes only tomato populations.

All investigated *P. infestans* field populations have rather different level of aggressiveness. Weak and aggressive strategies of viability support were revealed (table 4). Cluster analysis on strategies of viability support clearly indicated two kinds of *P. infestans* populations (fig. 4).

The first kind is characterized by weak substrategy W1 and includes potato populations of different origin (year of collection, location and cultivar), but all of them were treated with fungicides.

The second kind is characterized by both weak strategy and aggressive substrategies Al, A4 in different ratios. This kind includes potato populations of different origin (year of collection, location and cultivar) not treated with fungicides. At analysis of this group it is possible to distinguish subclaster with populations not treated with fungicides and subclaster with tomato populations.

It is interesting and important that no *P. infestans* oospores were detected in spite of the fact that many samples of blighted leaves were monitored and both Al and A2 mating

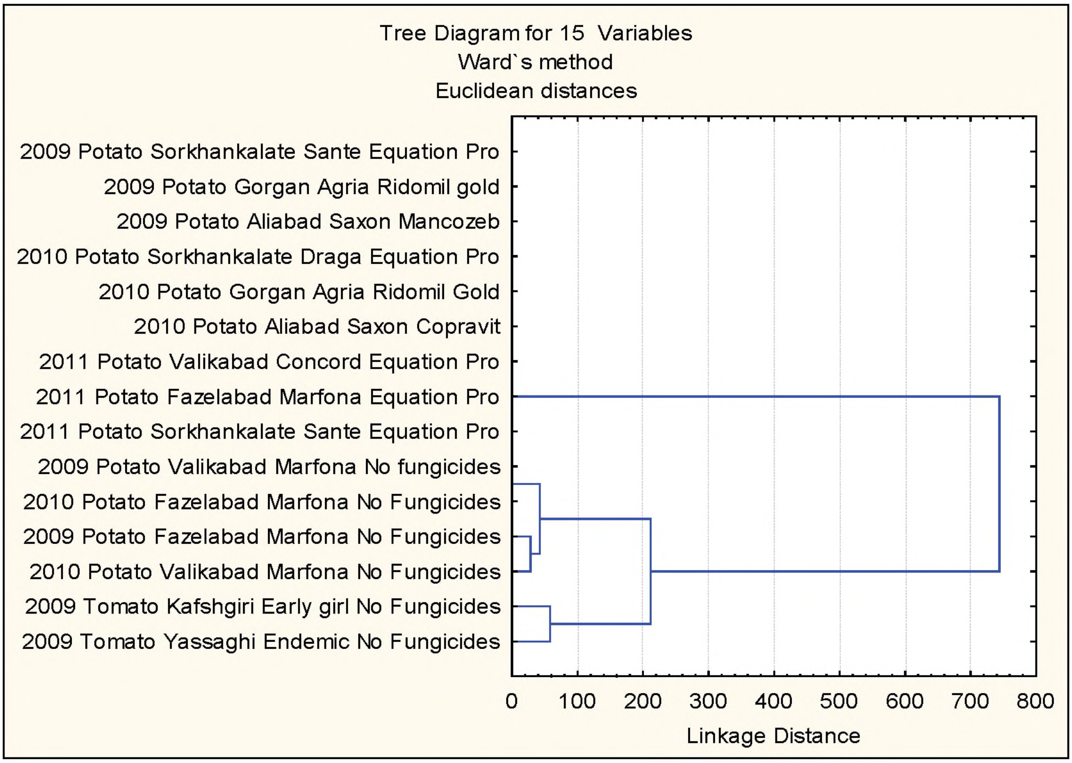

Fig. 4. Tree diagram for groups of potato and tomato field *P. infestans* populations according to their strategies of viability support

types were found in Golestan Iran (Zolfaghary A., unpublished data). This demands additional consideration.

The obtained results indicate to a quite strong level of late blight development in Iran Golestan both on potato and on tomato in spite of a rather warm climate. Susceptible potato cultivars without treatments were strongly blighted. Treatment with fungicides Ridomil Gold and Equation pro provided good protection against late blight as almost all *P. infestans* populations treated with these fungicides demonstrated suppressed features. Coprovit and Mancozeb were not so effective because these fungicides did not much suppress asexual stage of *P. infestans* in Golestan Iran.

Also it is important that imported tomato (Early Girl) was affected by late blight than local tomato. This supports the concept that imported host plants are affected by diseases stronger than the local aboriginal host plants. So imported host plants can be very dangerous for local aboriginal species as a source of infection [4].

Conclusions

Late blight is proved to be a very serious disease of potato and tomato in Iran. This disease can disturb ambitious plans to increase potato production and consuming for Iran population.

Late blight of potato and tomato is needed to be protected with modem fungicides. Otherwise, the crops would be highly suppressed with asexual *P. infestans* populations with different level of aggressiveness (including very aggressive populations under the Golestan conditions).

This investigation has clearly demonstrated that in spite of the current climate wanning *P. infestans* still can be very dangerous pathogen which must be carefully monitored both in Iran and in Russia.

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СТРАТЕГИЯ РАЗМНОЖЕНИЯ И ПОДДЕРЖАНИЯ ЖИЗНЕСПОСОБНОСТИ ООМИЦЕТА *PHYTOPHTHORA INFESTANS* В ИРАНЕ

Аннотация: статья посвящена жизненному и инфекционному циклам Phvtophthora infestans (Mont.) de Вагу *в иранской провинции Голестан. 3255 образцов листьев картофеля и томата, пораженных фитофторозом, собрали в 2009-2011 гг. из частных полей (0,5-4 га) 7районов. Всего изчили 123 полевых популяции патогена с картофеля и 30- с томата. Максимальные значения по распространенности, развитию, индексам встречаемости зооспорангиев и агрессивности зарегистрировали для полевых популяций патогена, против которых не применяли фунгициды. Наиболее агрессивными были популяции P. infestans на неместном сорте томата Early Girl. Напротив, вышеупомянутые показатели были низкими для картофельных популяций P. infestans, против которых применяли фунгициды Equation pro и Ridomil Gold. Все исследованные популяции P. infestans были бесполыми с различной интенсивностью образования зооспорангиев. Ооспоры не обнаружили. Полученные результаты убеждают в том, что, несмотря на потепление климата, P. infestans остается опаснейшим патогеном картофеля и томата и должен четко контролироваться как в Иране, так и в России.*

Ключевые слова: Phvtophthora infestans, фитофтороз картофеля, фитофтороз томата, Иран, Голестан, зооспорангии, стратегии размножения, стратегии поддержания жизнеспособности.

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