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Sources of resistance to late blight among *Andigena* accessions

Introduction

The problem of controlling late blight (LB) disease in potato production is still the main one both for potato producers and breeders in Russia. There are some potato varieties currently grown today which possess a relative resistance to this disease. Nevertheless new races of LB have appeared and they began to damage, destroy these varieties too. Thus, potato breeding based on supersensitive reaction determined by acting of some R-genes is insufficient. As to field resistance, it has a complex character and is inherited on a polygen base. It also can be defined by many factors, including the following: prolonged incubation period, slowed spreading of infection in plants, low sporulation, resistance to distribution of mycelium in on organism of host plant, after infiltration, ability to stop the development of sporangyes (2,5,8,11). Also, the field resistance of plants can be defined both collateral action of all enumerated factors, or only one of them.

In 1959, van der Zaag (13) ascertained, that the field resistance of varieties Foran and Nordling is based only on ability to suppression of spores and restricted sporulation. On the Hodsons (4) data the stability of variety Sebago is based only on stability to infiltration of spores. In a results of researches, Umaerus (11,12) detected that resistance to implantation of parasite play a main role in the protective mechanism of plant. He also detected that such type of resistance have the selected clones in Mexico.

Due to above mentioned statement potato investigations on study and evaluation of collection of cultivated species *S. andigenum* are very actual today. This specie was already noticed by plant breeders in some countries in 1950 - 60-s. It have participated in the creation of more than 750 breeding varieties and consequently is well known for the breeders as specie, which possesses such valuable traits for breeding as a high dry matter content and yield; resistance to pathogens and climatic stresses. It was known also, that *S. andigenum* possess some forms with high field resistance to LB and weak formation of sporangies. Exactly this specie have a highest polymorphism and quite wide differentiation of forms.

Geographical areas of this species lie through mountains and valleys of South and North America distancing up to 4000 km horizontally and up to 2000 km vertically. This specie was found growing in areas of 9 Latin American countries. Interaction of plants and the environments have influenced on a wide spectrum of variability under influence of various mutations, spontaneous hybridization and natural artificial selection. Just it became a main reason of such wide polymorphism of this specie and such high differentiation of its forms.

The analysis of long-term data on study of *S.andigenum* collection showed, that this specie was unjustly removed a background in the way of searching of new genetic sources of resistance to late blight.

Precisely for *S.andigenum* we have revealed the most legible expression of intraspecific differentiation of forms: since very susceptible up to resistant. The field resistance of the majority resistant forms is based on: long-lived incubation period; very weak sporulation of infection in plant.

The amount of *S.andigenum* forms in VIR Potato collection reaches 745 and the origin of these forms are 9 countries of Latin America, since Argentina up to Mexico.

Taking in account a presence of such differentiation, as well as presence of considerable number of accessions, which show on our annual observation a rather field resistance to late blight in years of LB epidemic, we have put the task of the next search of forms, resistant to late blight and having good inheritance of this trait to sexual progeny.

Material

In connection with stated above, revealing of genotypes having high field resistance to LB and transferring this trait in progenies from crosses and back crosses in polymorphous tetraploid cultivated specie *S. andigenum* was our task at the first stage (1993-95). At this preliminary stage of our researches, during which the plenty of samples was investigated, we have selected those forms, which during 3-4 years were not damaged by LB in field conditions. Thus, at this stage of researches 170 samples exhibiting 92 forms of *S. andigenum***,** shown field resistance were selected. It is necessary to note, that the degree of a defeat by illness of chosen samples within three years in field conditions has varied. It is connected with the fact that the weather conditions of vegetative period define a composition of races in a population of a fungi, which happens to be the most numerous in years of epidemics. So, in 1994, due to an abundance of precipitation in July and August up to 5 races of LB were registered and that created a hard background for an evaluation of samples. These, singled out during 3 years of tests 170 resistant samples, we have included in our studies on establishment of degree of inheritance of their field resistance in sexual progenies from self pollination and in crosses F1 and B1.For crossing we have used 16 breeding varieties with high fertility and compatibility.

Methods

LB resistance we have evaluated both in field and laboratory conditions by artificial infection by a mix of the most aggressive LB races.

The evaluation was led on 9 point’s scale. Infection was done two times by using high concentrated suspension: up to 30 conydies in a field of sight of microscope at 120 aliquot increase. Infection was conducted both on plants-seedlings in a phase of 5-6 leaf and leaf of adult plants. For artificial infection 250 seedlings of each accession was used. The degree of infection of seedlings was defined on though-tenth day. A field evaluation was done within 4-5 weeks from a beginning of the open form of LB display.

A degree of inheritance of resistance to LB we have studied in seedlings obtained from crosses of selected forms *S. andigenum* with breeding varieties S.*tuberosum*. Crosses were conducted on decapitated plants. In the crossing process *Solanum andigenum* samples were used both as male and as female forms.

Results

Preliminary analyses of our field data on resistance to LB in samples of S. andigenum has confirmed that high level of differentiation exists in many forms of this specy. Evaluated samples belong to 94 forms which in turn belong to 9 sub-varieties from 10 of this specy. Table 1 shows our 3 years experiments on evaluation of potato collection on resistance to LB. One can see that nearly every form has a certain quantity of resistant samples. This fact again proves high level of differentiation of S. andigenum. Moreover the biggest amount of resistant samples was found in the following subspecies – ssp.c*olombianum, bolivianum, argentinicum* and in Peruvian subspecies. Besides, we have found out that the more forms are in a sub-specie the most possible situation to find many resistant forms in it.

Our evaluation in 1996 of singled out samples by using the method of artificial inoculation of potato leaves, taken from tuber vegetative samples has proved availability of considerable amounts of resistant forms among them (Table 2).

At that time we also examined same samples by using the method of artificial inoculation of self-pollinated seedlings. Results of this examination showed high level of inheritance in sexual progeny and are presented in table 3.

In average, majority of sub-species gave high percent of resistance in 2/3 parts of samples. The amount of resistant samples in many subspecies was more then 50 %.

Next stage of our investigations was evaluation of inheritance to LB in progenies which were singled out among forms of *S. andigenum*. For this purpose all taken from field-laboratory evaluations 63 samples belonging to 9 sub-species were included in crosses. 77 crossing combinations were successful from total 85 crosses made with cultivated varieties. Next year (1997) the potato seedlings were grown up from F1 hybrid seeds in order to evaluate level of inheritance of resistance to LB. Table 4 reflects data of the10 best, in our conclusion, combinations, in which, under segregation, amount of resistant forms consisted from 53 up to 84 %. Moreover, from all tested combinations we have taken 30 which under segregation amount of resistant seedlings exceeded 30 %. These F1 hybrids we used in consequent examination. In 1998 we made a field evaluation of F1 tuber propagation. In the table 5 we show data on 12 best hybrids. They possess high resistance to LB both in field and laboratory tests (artificial inoculation of leaves) and have high productivity and quality of tubers. This material we intend to use in our future work.

Table 1 Differentiation of S. *andigenum* Juz.et Buk. accession on field resistance to Late blight

(Poushkin, St.Petersburg, 1993-95)

	Subspecies	Num of frms	Num of accs	Distribution on resistance			
				S	MR	R	% R
1	*COLOMBIANUM*	15	102	51	15	36	35
2	MEDIAMERICANUNM	5	56	39	08	9	16
3	*RIMBACHI*	3	24	19	3	2	8
4	*ECUATORIANUM*	2	30	24	1	5	16
5	*TARMENSE*	10	87	56	11	20	23
6	*CENTRALIPERUVIANUM*	14	82	49	16	17	21
7	*AUSTRALIPERUVIANUM*	18	91	52	15	24	26
8	*BOLIVIANUM*	15	83	43	10	30	36
9	*ARGENTINICUM*	12	95	48	7	30	31
	Total	94				170	

Table 2. Resistance of selected accessions to LB in conditions of artificial LB infection of leaves

	Subspecies	Num of form	Num of accs	Distribution on resistance			
				S	MR	R	% R
1	*COLOMMBIANUM*	7	36	9	2	25	69
2	*MEDIAMERICANUM*	2	9	6	0	3	3
3	*RIMBACHI*	2	2	1	0	1	50
4	*ECUATORIANUM*	1	5	0	2	3	60
5	*TARMENSE*	9	20	3	1	16	80
6	*CENTRALIPERUVIANUM*	7	17	4	0	13	76
7	*AUSTRALIPERUVIANUM*	11	24	4	2	18	75
8	*BOLIVIANUM*	14	24	3	1	20	83
9	*ARGENTINICUM*	10	30	7	0	23	76
Total		63	170				

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1	COLOMMBIANUM	7	36	9	2	25	69
2	MEDIAMERICANUM	2	9	6	0	3	3
3	RIMBACHI	2	2	1	0	1	50
4	ECUATORIANUM	1	5	0	2	3	60
5	TARMENSE	9	20	3	1	16	80
6	CENTRALIPERUVIANUM	7	17	4	0	13	76
7	AUSTRALIPERUVIANUM	11	24	4	2	18	75
8	BOLIVIANUM	14	24	3	1	20	83
9	ARGENTINICUM	10	30	7	0	23	76
Total		63	170				

Table 3. Resistance by artificial infection of seedling from self pollination of selected accessions.

	Subspecies	Num of frms	Num of accs	Distribution on resistance			
				S	MR	R	%R
1	*COLOMBIANUM*	7	36	14	3	19	53
2	*MEDIAMERICANUM*	2	9	5	0	4	44
3	*RIMBACHI*	2	2	0	0	2	100
4	*ECUATORIANUM*	1	5	3	0	2	40
5	*TARMENSE*	9	20	4	4	12	60
6	*CENTRALIPERUVIANUM*	7	17	2	0	15	88
7	*AUSTRALIPERUVIANUM*	11	24	5	2	17	71
8	*BOLIVIANUM*	14	30	4	3	23	76
9	*ARGENTINICUM*	10	30	11	1	18	60
	Total		170				

Table 4. Segregation of seedlings from self pollination of *S. andigenum* Juz.et Buk forms on resistance to late blight in artificial infection

Hybrids F1 F x M	Num of sdls	Distribution of seedlings on resistance			
		S	MR	R	% R
SCALA x K-5233 var.*tolucanum*, ssp.*mexicanum*	216	47	16	153	71
GRATA x K-15559 var.*mammiforme*, ssp. *colombianum*	234	82	27	125	53
NEVSKII x K-1689,var.caiceda, ssp. *colombianum*	205	53	21	131	64
ORBITA x 15645, var,*quina*, ssp. *colombianum*	198	53	9	138	70
ANKO x K-15646, ssp. *colombianum*	211	24	17	118	56
ORBITA x K-4611 ssp. *bolivianum*	223	59	6	158	71
WILLIJA x K-15303 ssp. *runa*	187	12	10	156	84
K-4005, var.c*atarthrisimile*,ssp.*argentinicum* x DORISA	196	68	13	115	59
K-5774, var.*Pucca paltacc*,ssp.*centraliperuvianum* x APTA	204	44	25	135	66
K-16440 var. *sihuanum*, ssp. *australiperuvianum* x DORISA	196	68	13	115	59

Table 5. The field resistance to late blight of selected hybrids with *S.andigenum* Juz. Et Buk. forms

N	Crossing combinations	Pro-geny	Num Of Plan	Distribution on resistance			
				S	MR	R	% R
1	Liseta x K-15597 var.*tocanum*,ssp.*colombianum*	F1	96	19	6	71	74
2	Nevski x K1689, var.*caiceda*, ssp. *colombianum*	F1	72	10	3	59	82
3	Gloria x K-3154, var.*catamarcense*,ssp.*argentinicum*	F1	65	14	8	43	66
4	K-15543,var.*tocanum*,ssp.*colombianum* x Granola	F1	49	14	7	28	58
5	K-15533,var.*Guata blanca*, ssp.*colombianum* x Nevskii	B1	64	9	3	52	81
6	(Orbita x Bison) x K-10392 var. *chola ssp.ecuatorianum*	B1	68	25	9	34	52
7	K-17602, ssp. *australiperuvianum* x Desiree	B1	92	27	2	63	69
8	(K-16440, var. *sihuanum*, ssp.austrperuvianum x Vesna) x Dorisa	B1	85	12	7	66	78
9	(Adretta x K-15361, ssp. *mexicanum*) x Gloria	B1	64	6	4	54	84
10	(Orbita x Willja) x K-15303 ssp. *runa*	B1	90	26	4	60	67
11	(Anco x Orbita) x K-15559, var.*mammiforme*, ssp.*australiperuvianum*	B1	75	12	11	52	69
12	(Nevskii x Granola) x var.*quina*, ssp.*colombianum*	B1	63	9	6	48	77

Conclusions

Numerous crosses of forms of S. *andigenum* with breeding varieties showed that genetic diversity of this specie open a great possibilities to carry out the potato breeding programs on resistance to LB. These crosses also show that in combinations S. *tuberosum* (T) with S. *andigenum* (A) and A x T possibility to obtain hybrids with complex traits (resistance to LB and other pathogens, high yield and good quality of tubers) is obvious and great. Development of such hybrids is easily done due to sufficiently easy crossing ability of considerable majority forms of S. *andigenum* with breeding varieties and other potato species.

Thus, as a result of our investigations we have singled out resistant forms of *S. andigenum* introduced from central part of Mexico, as well as from Columbia and Argentina. Climatic and environmental conditions in these countries have favored mutation variation of plant genotypes, their selection and survival in conditions of severe and strong infection loading of fungi spores of *Phytopthora infestans* Mont de Bary.

This article does not contain any detail data of our analytic investigations on growing areas of *S. andigenum*'s samples, introduced in different time from 9 South American home countries of this specie. We would like shortly to point out in this article that this evaluation allowed us to determine possible areas of concentration of genetic sources to resistance to potato LB. We, together with Dr. Budin K. Z., have established that such places of concentration of resistant forms are micro-ecological niches located in mountain regions of South America where climatic conditions were favorable to development of LB fungi. For example, in Argentina, such a niche is determined in states Salta and Tukuman, 25 degrees of southern latitude and 65 degrees of western longitude, at height from 1720 m up to 3700 m above sea level. 7 samples of *S. andigenum*, introduced from this district had high resistance to several LB races. The similar ecological niches are established by us in Bolivia, province Cochabamba, 19,5 degrees of southern latitude, 66 degrees of western longitude, and also in Colombia and Peru. Such growing points (places) of resistant forms are defined as well for other potato species.

The discovery of such ecological niches once again has confirmed known law of N. Vavilov about homologous rows and differentiation of species. It also reconfirms such fact, for example that similar forms, introduced from other places of the above named countries are susceptible to LB.

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