Late blight resistance of potato hybrids with diverse genetic background

E. Rogozina, M. Kuznetsova,
O. Fadina, M. Beketova,
E. Sokolova and E. Khavkin

EuroBlight workshop 14-17 May 2017, Aarhus, Denmark

Objects of study

Clone	Maturity	Background	*Solanum* spp.
117-2	Intermediate	F1	*S. alandiae*
25-1-2007	Intermediate	BC1	*S. alandiae*
99-4-1	Intermediate	BC2	*S. stoloniferum*
171-3	Intermediate	F2 BC1	*S. andigenum*, *S. rybinii*
160-17	Intermediate to late	F2 BC1	*S. andigenum*, *S. rybinii*
194-4т	Early to intermediate	BC2 (Fn)	*S. andigenum*, *S. phureja*, *S. stoloniferum*
34-5-2003	Early to intermediate	Fn	*S. andigenum*, *S. rybinii*, *S. phureja*, *S. stoloniferum*
91-19-3	Intermediate to late	Fn	*S. andigenum*, *S. rybinii*, *S. acaule*, *S. bulbocastanum*, *S. stoloniferum*
93-5-30	Intermediate	Fn	*S. andigenum*, *S. rybinii*, *S. phureja*, *S. acaule*, *S. bulbocastanum*, *S. stoloniferum*
18/40-2000	Intermediate to late	BC2F2 × BC2F1	*S. andigenum*, *S. demissum*, *S. stoloniferum*, *S. polytrichon*, *S. simplicifolium*
Nayada St	Intermediate		

Potato collection maintained in the N.I. Vavilov Institute of Plant Genetic Resources comprises more than 120 potato hybrid clones developed and recommended as sources of useful breeding traits.

We examined 10 clones originating from different parental lines and carrying the genetic material from one to six *Solanum spp.* These clones were selected initially among related individuals because of a high LB resistance (scored 7-8) and a similarity in the appearance of plants and tubers to cultivated potato. Clones belong to the intermediate maturity group or neighbor ones.

Objective: to assess the durability of potato LB resistance

and its effect on tuber yield.

Methods of study: Phenotypic and genetic profiling of potato hybrid clones based on:

- Field trials at the Pushkin Experimental station of VIR in St. Petersburg during nine cropping seasons 2008-2016. Ten plants per plot in two repetitions planted in a randomized design into a common field of the potato collection.

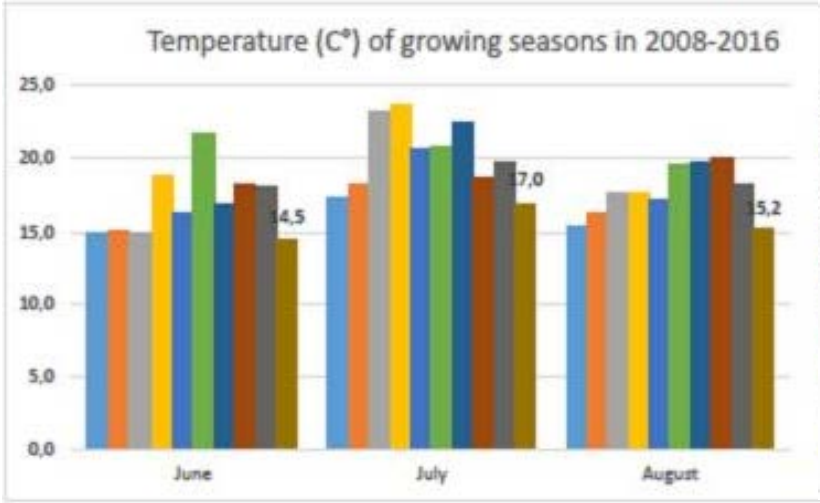
Area of leaf affected by diseases, maximum disease induced damage in potato plants and tuber yields were recorded.

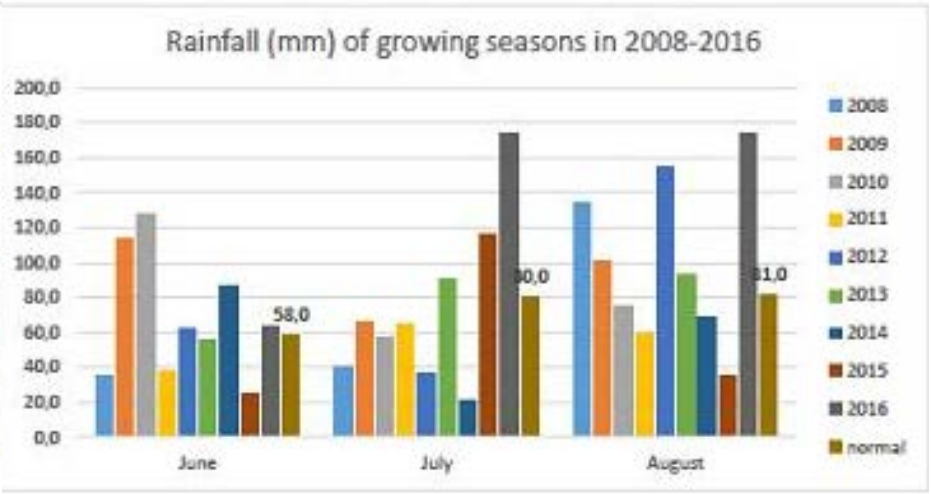
- Laboratory test on detached leaves, 3 leaves per clone in two repetitions inoculated with an isolate of *P. infestans* comprising all virulence genes, A1 mating type and a high aggressiveness.

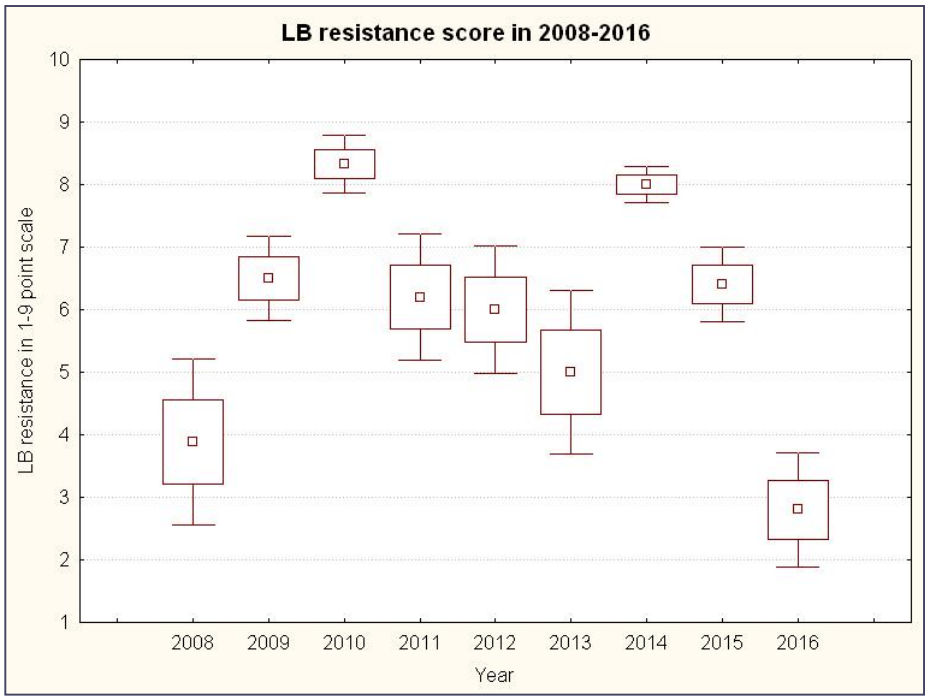
Area of plant tissue occupied by infection spot and intensity of sporulation were recorded.

- Assay for SCAR markers of already known *Rpi* genes.
- Characteristics of *P. infestans* isolates collected from tested potato clones in 2013 and 2014

Climatic conditions in nine cropping seasons







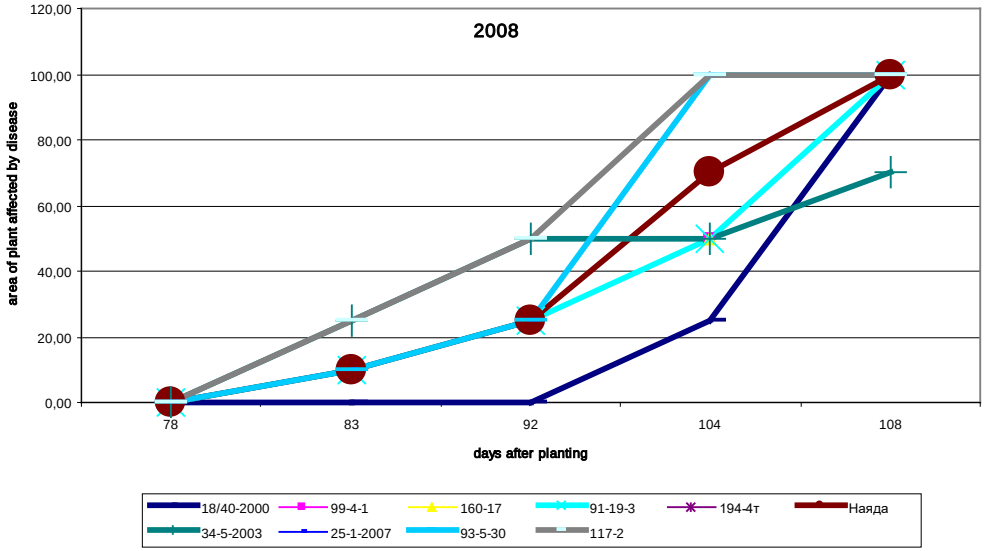
The weather conditions were the most favorable for LB infection in 2008 and 2016, so the fastest and strongest potato damage was recorded in both cropping seasons.

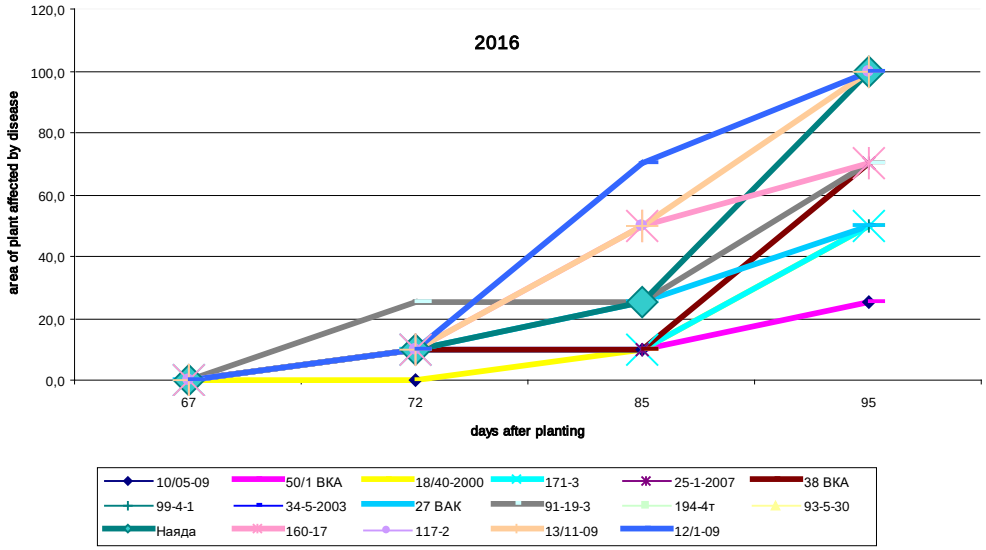
In 2013 LB emergence was also notable.

In 2009, 2011, 2012 and 2015 disease progressed slowly because of weather changes in summer.

In 2010 and 2014 LB infestation was observed only at the end of season.

AUDPC of ten potato clones in two years the most favorable for LB

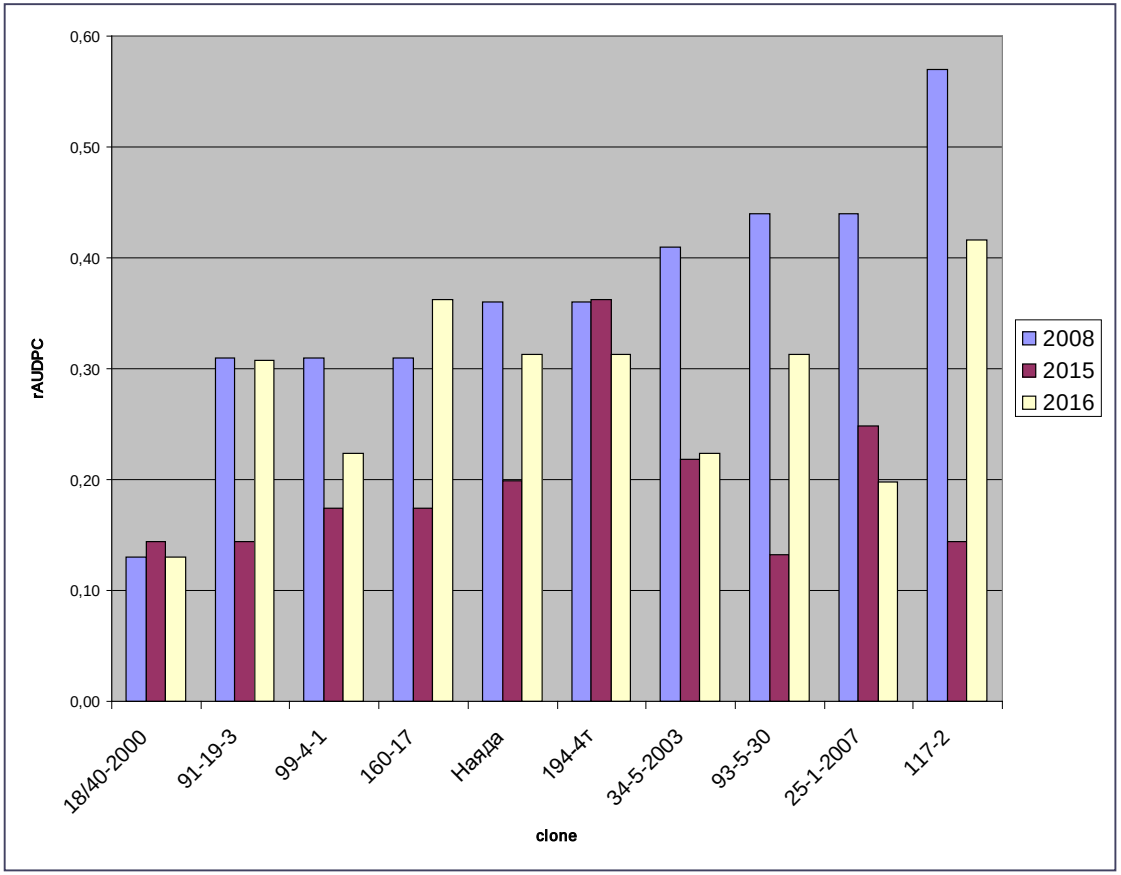




In 2008 and 2016 initial LB symptoms on cv. Bintje were noted at 78th and 67th day after planting, respectively.
Cv. Sarpo Mira was used as a resistant standard. In both field trials this cultivar manifested high LB resistance and differed from all tested clones by late maturity.

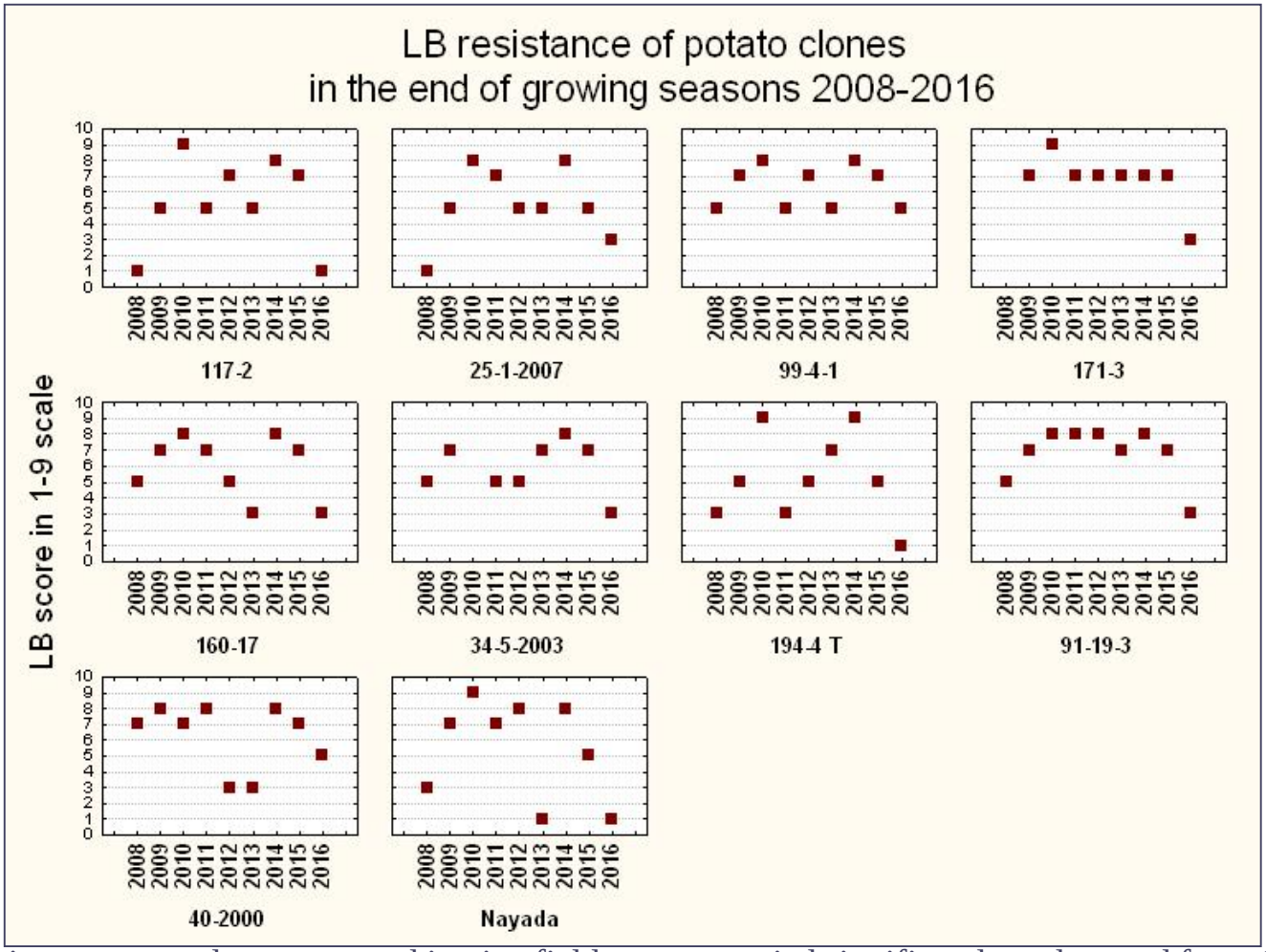
Disease development was assessed 4-5 times until the end of cropping seasons.
The AUDPC patterns in 2016 matched those of 2008 on a general set of tested potato.
Results of two-year AUDPC assessment were only similar for two potato clones.
In 2008 and 2016 clone **18-40-2000** was classified as **the most resistant** among tested material, and clone **117-2** was found **the most susceptible**. Other clones and cv. Nayada have changed their ranks (positions) in 2016 comparatively data of LB development in 2008.

rAUDPC of potato clones in 2008, 2015 and 2016



rAUDPC values of ten tested potato clones ranged from 0.13 to 0.57 in three field experiments.
The Friedman ANOVA rank test indicated significant year-by-year variation in rAUDPC value in field tests (Chi-square$_{Friedman}$ = 6.95 > χ2 (o.o5)=5.99). Clone **18/40-2000** had the smallest rAUDPC value **(0.13-0.14)** in all three years. Clone 117-2 has the biggest rAUDPC value (0.42-0.57) in 2008, 2016 and has rAUDPC value (0.14) equal to rAUDPC value of clone 18/40-2000 in 2015. Kendall's *W* (Kendall's coefficient of concordance) = 0.24 indicated weak coherence in year-by-year potato response to LB infection.

Maximum disease-induced damage in potato plants



Final damage in ten potato clones assessed in nine field seasons varied significantly and ranged from 1 to 9. ANOVA indicated that the factor «year» significantly affected disease severity in tested clones. F=15.3 >3.4.

Clone **99-4-1** manifested the most stable response to LB infestation in all years of field trials. No more than 50% of leaf area of clone 99-4-1 was affected by disease in any year of assessments. Value of rAUDPC calculated for clone 99-4-1 did not exceed 0.31.Clone **18-40-2000** was affected by LB in 2012 and 2013 stronger than in others years of trials.

LB resistance assessed as rAUDPC and in the detached leaf test

Potato clone	rAUDPC 2015	rAUDPC 2016	Detached leaf test*
117-2	**0.14**	**0.42**	**5 MS**
25-1-2007	**0.25**	**0.20**	**5 MS**
194-4т	**0.36**	**0.31**	**5 MS**
34-5-2003	**0.22**	**0.22**	**5 MS**
93-5-30	**0.13**	**0.31**	**4 MS**
18/40-2000	**0.14**	**0.13**	**4 MS**
38 KBA	**0.10**	**0.20**	**6.5 MR**
15/13-09	**0.10**	**0.22**	**6 MR**
16/27-09	**0.10**	**0.31**	**7 MR**
Sarpo Mira	**0.06**	**0.08**	**7 MR**

***Points by 1-9 scale and the level of resistance: MS – moderately sensitive, MR – moderately resistant, R – resistant**

The laboratory assays proved a moderate LB sensitivity of potato clones. Results of the field trials in St. Petersburg coincident the data from numerous trials in another location, the experimental plot of the Institute of Phytopathology (Moscow region). Results of field trials in two last years and laboratory assay indicated a significantly moderate level of agreement: Kendall's $W = 0.43$.

New prospective potato clones 15/13-09, 16/27-09 and 38KBA were recently selected in the VIR collection. These clones manifested LB resistance in laboratory assays equal to resistance of cv. Sarpo Mira. Preliminary field trials of these clones at both locations (Moscow and St. Petersburg) confirm their superiority.

Potato clone	Detached leaf test*	Productivity g/plant, min-max
117-2	**5 MS**	**550-1160**
25-1-2007	**5 MS**	**480-1000**
99-4-1	**4.5 MS**	**475-860**
160-17	**nd**	**660-1150**
194-4т	**5 MS**	**550-1400**
34-5-2003	**5 MS**	**400-930**
91-19-3	**nd**	**370-1160**
93-5-30	**4 MS**	**550-910**
18/40-2000	**4 MS**	**520-1200**
cv. Nayada	**nd**	**620-1100**

*Points by 1-9 scale
and the level of resistance:
MS – moderately sensitive.

Tuber yield

produced by potato clones in nine cropping seasons greatly varied.

Two-way analysis of variance (ANOVA) indicated that the factor «year of trial» significantly affected the tuber yield:

$F=15.4$ ($n=8$) >3.4 ($p<0,001$).

Final score of disease severity and tuber yield did not correlate ($r=0.26$, $p<0,001$)

Genetic profile of potato clones

ANTICIPATORY BREEDING: MOLECULAR MARKERS AS A TOOL IN DEVELOPING DONORS OF POTATO (*Solanum tuberosum* L.) LATE BLIGHT RESISTANCE FROM COMPLEX INTERSPECIFIC HYBRIDS. *O.A. Fadina, M.P. Beketova, E.A. Sokolova, M.A. Kuznetsova,T.I. Smetanina, E.V. Rogozina, E.E. Khavkin.* ***Agricultural Biology*** 2017, 52 (1): 84-94.

Clones	Detached leaf test*	*Rpi genes*
117-2	**5 MS**	*R2, R3b, Rpi-vnt1.3*
25-1-2007	**5 MS**	*R3b*
99-4-1	**4.5 MS**	*R1, R3b*
171-3	**6 MR**	*R3b*
160-17	**Nd**	Nd
194-4т	**5 MS**	*R3b, RB-blb1*
34-5-2003	**5 MS**	Nd
93-5-30	**4 MS**	*R3b*
18/40-2000	**4 MS**	*R1, Rpi-vnt1.3*
cv. Nayada	**Nd**	*R1, R2*

SCAR markers, the fragments of six *R* genes:
R1 (chromosome 5),
R2/*Rpi-blb3* (chromosome 4),
R3a and *R3b* (chromosome 11),
RB/*Rpi-blb1* = *Rpi-sto1* (chromosome 8),
and *Rpi-vnt1.3* (chromosome 9),
were employed to screen the potato clones.

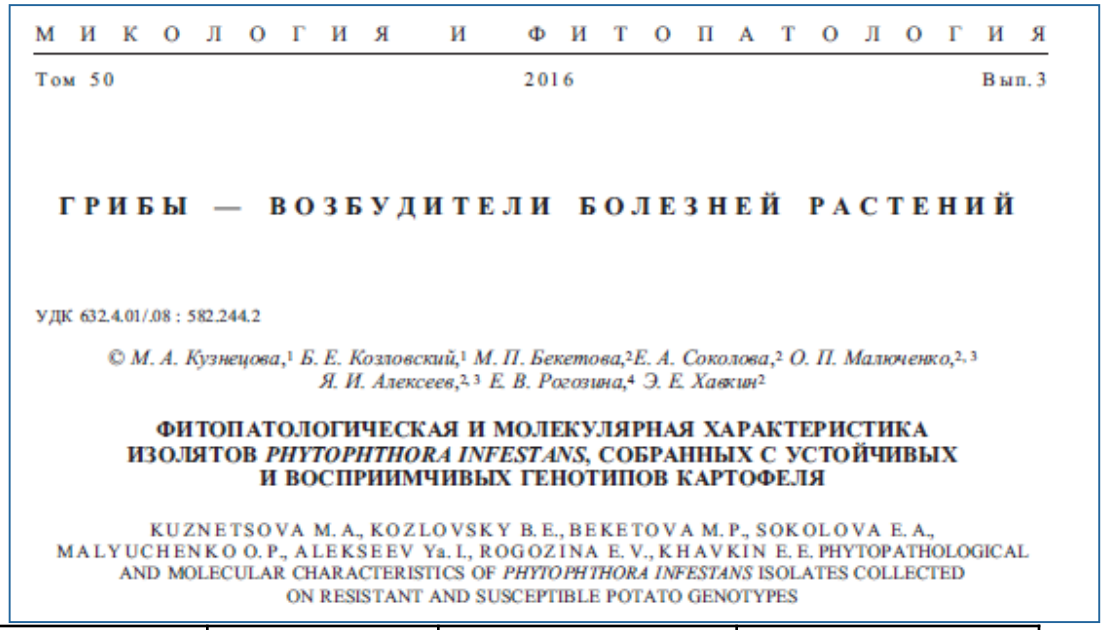
SCAR markers were found in cv. Nayada and seven potato clones (with exception of 34-5-2003). Clones have various origins and possess one or combination of two or three different SCAR markers. The relationship between the field resistance and *Rpi* gene profile of potato clones is not evident and has to be studied additionally. Stable and sufficient response of clone 99-4-1 to LB infestation is apparently based not only on *Rpi* genes. This clone is one of the most probable sources of race non-specific LB resistance.

*Points by 1-9 scale and the level of resistance: MR – moderately resistant; MS – moderately sensitive.

P. infestans isolates colonizing potato clones

Phenotypic characteristics and SSR profiles of *P. infestans* isolates collected on the same potato clones in two subsequent years considerably changed in several criteria..

The changes in virulence gene spectra, mating type, sensitivity to metalaxyl and aggressiveness of *P. infestans* isolates colonizing the same potato genotypes in different years can explain variation in response of potato clones to LB infestation in the field tests.



МИКОЛОГИЯ И ФИТОПАТОЛОГИЯ

Том 50 2016 Вып. 3

ГРИБЫ — ВОЗБУДИТЕЛИ БОЛЕЗНЕЙ РАСТЕНИЙ

УДК 632.4.01/.08 : 582.244.2

© М. А. Кузнецова,[1] Б. Е. Козловский,[1] М. П. Бекетова,[2] Е. А. Соколова,[2] О. П. Малюченко,[2, 3] Я. И. Алексеев,[2, 3] Е. В. Рогозина,[4] Э. Е. Хавкин[2]

ФИТОПАТОЛОГИЧЕСКАЯ И МОЛЕКУЛЯРНАЯ ХАРАКТЕРИСТИКА ИЗОЛЯТОВ *PHYTOPHTHORA INFESTANS*, СОБРАННЫХ С УСТОЙЧИВЫХ И ВОСПРИИМЧИВЫХ ГЕНОТИПОВ КАРТОФЕЛЯ

KUZNETSOVA M. A., KOZLOVSKY B. E., BEKETOVA M. P., SOKOLOVA E. A., MALYUCHENKO O. P., ALEKSEEV Ya. I., ROGOZINA E. V., KHAVKIN E. E. PHYTOPATHOLOGICAL AND MOLECULAR CHARACTERISTICS OF *PHYTOPHTHORA INFESTANS* ISOLATES COLLECTED ON RESISTANT AND SUSCEPTIBLE POTATO GENOTYPES

Potato clone	Year of isolate collection	Virulence genes	Mating type	Metalaxyl sensitivity*	Aggressiveness (mean value)
93-5-30	2013	124561011	A2	S	nd
	2014	124561011	A1	S	moderate
171-3	2013	1234567891011	A1	MS	moderate
	2014	12345671011	A1	S	moderate
25-1-2007	2013	1234567891011	A2	MS	moderate
	2014	12345671011	A1	S	high

*S – sensitive; MS – moderately sensitive

Conclusions

- In genetically different clones of interspecies potato hybrids, LB resistance values in the field vary, the vector of changes is different and depends on the year of the test.
- Clone 99-4-1 was characterized by medium or high resistance to LB during 9 years of field testing.
- The variability of *P. infestans* isolates in the experimental field of the VIR potato collection provides a balanced polymorphism in the population that promotes the survival of the pathogen in the genetically diverse pool of the host plant.
- In the Pushkin location, with its highly diverse collection of potato genotypes, the primary infection of LB can arise from multi sources, and none of the present pathotypes dominates. These pathotypes compete and are apparently selected due to a trade-off between pathogenicity and plant resistance (D. Andrivon et al. 2013, C. Pasco et al. 2016).
- Long-term potato trials in the experimental field of the VIR collection, even under conditions of high infestation, are insufficient to determine the reliable genotype reaction to late blight.
- Evaluation of the interspecies potato hybrid clones under heavy artificial infestation with aggressive and highly virulent *P. infestans* strains allows to assess the level of clone resistance to LB.

Acknowledgment

This research was support by Russian Foundation for Basic Research (RFBR)
Project 16-04-00098:
Molecular genetic analysis of the interaction of plants with pathogens
(on the example of potato late blight).