The evaluation method of potato genotype resistance to blackspot bruise

J. Domkářová, B. Vokál

Potato Research Institute, Havlíčkův Brod, Česká republika

ABSTRACT

In 2001–2003 a method for the evaluation of potato genotype (genetic resource) resistance to blackspot bruise was verified. Thirty tubers of 25 varieties and hybrids of *Solanum tuberosum* L. were evaluated using electronic pendulum MIDAS 88P. The analysis of variance showed a significant difference among the individual varieties and hybrids and among years as well. An evaluation scale was established for the assessment of potato genotype (genetic resource) resistance to blackspot bruise. Varieties and hybrids were included in the new designed evaluation scale in scores of 7 (high resistance) up to 9 (very high resistance), which could be regarded as suitable genetic resources in breeding for the improvement of this character. From the evaluated set, the suitable varieties are: Carmona, Agria, Annabelle, Futura, Impala, Adora, Granola and Inova and the suitable hybrids: YP 91-123 and VDW 94-76.

Keywords: potato; *Solanum tuberosum* L.; blackspot bruise; pendulum; potato genotypes; potato genetic resources

Discolouration of potato tubers is a serious problem for potato growers and processors. It leads to increased costs due to growth losses and the application of the necessary measures that are needed to decrease losses during processing (Dale and Mackay 1994). Potato blackspots occur in peeled tubers, in which external or internal bruises caused by the potato's mechanical damage are present. Enzymatic discolouration is caused by the oxidation of tyrosine and other ortho-dihydrogenic phenols by polyphenol oxidase (PPO) causing the production of dark or black melanine pigments. The blackspot bruise depends on a variety of chemical compounds (Hamouz et al. 1997, Delgado et al. 2001b), in which year, variety, water regime, storage and also nutrition, mechanical damage and tuber de-sprouting affects its content. Various methods of determining tuber resistance to blackspot bruise are used worldwide. Using methods based on pendulum and shaking, tubers are subjected to short-term mechanical forces and long-term pressure (Molema 1999). Other methods enable a comparison of tubers based on chemical and biochemical tuber composition (Delgado et al. 2001a). Breeding for resistance to mechanical damages associated with blackspot bruise is more successful, when resistant parents with backcross potential are used. A highly significant effect of common combining ability and specific combining ability was recorded on this characteristic (Pavek et al. 1993). The utilization of *S. hjertingii* as a source of genetic factors, which introgressed in germplasm of the cultivated potato that inhibit blackspot bruise, is also possible (Brown et al. 1999).

The aim of the study is verification of a pendulum-based method for the evaluation of tuber samples in selected genotypes originating from potato genetic resource collection, and/or in clonal selection for resistance to blackspot bruises.

MATERIAL AND METHODS

The method was verified in the tubers of 25 varieties and hybrids of *Solanum tuberosum* L. originating from a potato genetic resource collection. Thirty tubers of each variety and hybrid were included in the testing for three years (2001–2003). The 2001 and 2002 samples were tested following three-months and in 2003 following a four-month-storage period. An electronic pendulum MIDAS 88 P was used for the evaluation and included the recommended methodology (Gall 1994). Prior to testing tuber material was stored at 4–6°C for 10 days. A low tuber temperature was also retained during the evaluation. The tuber was injured by two impacts of 277.7 mJ at one location. The impact location was not visually damaged and it was marked for

Supported by the Ministry of Agriculture of the Czech Republic, Projects Nos. QE 1174 and 33083/03-3000.

Table 1. Mean resistance of selected potato genotypes to blackspot bruise in 2001–2003

Variety (hybrid)	Evaluation score (*ES*)			Blackspot index		
	mean	*SD*	mean *SE*	mean	*SD*	mean *SE*
Monika	2.06	0.62	0.36	21.22	14.87	8.59
YP 94-067	1.69	0.29	0.17	13.33	5.17	2.99
Westamyl	2.68	0.62	0.36	31.67	9.39	5.42
BEE J85 113 54	2.25	0.42	0.24	26.10	8.96	5.17
Futura	1.23	0.32	0.18	4.33	6.64	3.83
Santana	1.97	0.20	0.12	19.67	4.92	2.84
Samanta	1.90	0.48	0.28	16.78	10.38	5.99
Ornella	1.74	0.24	0.14	13.22	6.61	3.82
Agria	1.28	0.15	0.09	3.67	2.96	1.71
JAN A 87 193 39	1.70	0.37	0.21	15.33	8.94	5.16
Granola	1.48	0.13	0.08	7.66	3.48	2.01
VDW 94-76	1.41	0.13	0.07	6.33	2.96	1.71
Viola	2.06	0.28	0.16	20.11	5.98	3.45
Santé	1.69	0.20	0.11	13.78	3.03	1.75
YP 91-123	1.30	0.07	0.04	5.00	1.34	0.77
Carmona	1.27	0.09	0.05	3.55	1.84	1.06
Ramos	1.87	0.66	0.38	16.67	15.25	8.80
Annabelle	1.34	0.10	0.06	3.89	1.50	0.87
Impala	1.33	0.12	0.07	4.88	2.12	1.22
Karin	2.30	0.06	0.03	25.67	1.20	0.69
Inova	1.43	0.26	0.15	8.55	6.26	3.61
Adora	1.32	0.30	0.17	5.00	6.06	3.50
Kornelie	1.80	0.35	0.20	13.55	7.43	4.29
Tomensa	1.61	0.35	0.20	14.56	3.56	2.06
Kreta	1.64	0.07	0.04	12.00	1.53	0.88
Mean	1.69			13.04		
SD	0.38			7.87		
VC	22.13			60.39		
Analysis of variance						
F-test varieties	4.825**			4.587**		
years	6.144**			5.169**		
Min *SD*						
varieties $\alpha = 0.01$	1.0608			22.8284		
$\alpha = 0.05$	0.9156			19.7038		
year $\alpha = 0.01$	0.2586			5.5626		
$\alpha = 0.05$	0.2035			4.3789		

evaluation. Injured tubers were stored at 17°C for 10 days. Each impact location was vertically cut and included in one of 5 scores: 1 – without discolouration, 2 – discolouration up to depth of 4 mm, 3 – discolouration 4–8 mm, 4 – discolouration 8–12 mm, 5 – discolouration more than 12 mm.

Mean evaluation score, mean standard error and blackspot bruise index were calculated each year for comparison of discolouration intensity of individual varieties and hybrids. For index calculation, at first the percent portion of discoloured tubers in evaluation scores was determined, which was arranged in the following way: percent presence in the first score was multiplied by factor 0, in the second score by 0.1, in the third score by 0.4, in the fourth score by 0.7 and in the fifth score by 1.0. The resulting index was determined by the sum of products derived in the individual evaluation scores. Three-year mean evaluation scores and mean blackspot bruise indices were calculated for all varieties and hybrids, with the standard deviation and mean standard error. The results were processed in analysis of variance; as parameters varieties and hybrids (25 varieties and hybrids) and year of growing (2001–2003) were used. A nine-score evaluation scale of resistance to blackspot bruise was determined according to the mean blackspot bruise index and the evaluated varieties and hybrids were classified according to this scale. The correlation coefficient was determined for assessment of relation between years.

Table 2. Resistance of selected potato genotypes to blackspot bruise in 2001

Variety	Mean *ES*	Mean *SE*	Portion of tubers (%) according to *ES*					Blackspot index
			1	2	3	4	5	
Monika	2.07	0.19	40.00	20.00	33.33	6.66		19.99
YP 94-067	1.43	0.16	76.67	6.66	13.33	3.33		8.33
Westamyl	2.67	0.18	20.00	10.00	53.33	16.67		34.00
BEE J 85 113 54	1.87	0.24	63.33	10.00	6.66	16.67	3.33	18.66
Futura	1.03	0.03	96.67	3.33				0.33
Santana	2.20	0.23	46.67	6.66	26.67	20.00		25.34
Samanta	1.50	0.12	60.00	30.00	10.00			7.00
Ornella	1.70	0.15	50.00	30.00	20.00			11.00
Agria	1.27	0.08	73.33	26.67				2.67
JAN A 87 193 39	1.30	0.15	80.00	16.67			3.33	5.00
Granola	1.40	0.11	66.67	6.66	6.66			5.33
VDW 94-76	1.47	0.10	56.67	40.00	3.33			5.33
Viola	2.37	0.21	30.00	23.33	26.67	20.00		27.00
Santé	1.47	0.14	70.00		16.67	13.33		16.00
YP 91-123	1.23	0.10	83.33	10.00	6.66			3.66
Carmona	1.23	0.08	76.67	23.30				2.33
Ramos	1.67	0.15	53.33	26.67	20.00			10.67
Annabelle	1.40	0.09	60.00	40.00				4.00
Impala	1.30	0.10	73.33	23.30	3.33			3.66
Karin	2.37	0.19	30.00	13.33	46.67	10.00		27.00
Inova	1.57	0.13	56.67	30.00		13.33		12.33
Adora	1.13	0.06	86.67	13.33				1.33
Kornelie	1.53	0.13	60.00	26.67	13.33			8.00
Tomensa	1.97	0.17	43.33	16.67	40.00			17.67
Kreta	1.67	0.19	66.67	6.67	20.00	6.66		13.33
Mean	1.632							11.60
SD	0.426							9.34
VC	26.103							80.56

RESULTS AND DISCUSSION

Mean resistance to blackspot bruise of evaluated genotypes originating from potato genetic resource collection in 2001–2003, expressed in the mean evaluation score and the mean blackspot bruise index included a standard deviation and mean standard error, and is given in Table 1. From the results it is apparent that using a blackspot bruise index for evaluation of resistance to blackspot bruise, which better expresses a higher variability among varieties, was the right decision. Variation coefficient was recorded 22.13% for the mean evaluation score and 60.39% for the mean blackspot bruise index. Compared to the mean evaluation score, blackspot bruise index especially takes into account the occurrence of tubers with higher damage, as concluded from Tables 2–4.

The analysis of variance for the recorded values shows significant differences both among individual genotypes and years. It is a character, to which the expression of genotypic and environmental effects contributes. It confirmed the findings of Delgado et al. (2001b), who also found other effects

Table 3. Resistance of selected potato genotypes to blackspot bruise in 2002

Variety	Mean *ES*	Mean *SE*	Portion of tubers (%) according to *ES*					Blackspot index
			1	2	3	4	5	
Monika	1.43	0.13	70.00	16.67	13.33			7.00
YP 94-067	1.63	0.20	70.00	10.00	6.66	13.33		12.99
Westamyl	3.30	0.25	20.00	6.66	10.00	50.00	13.33	39.67
BEE J 85 113 54	2.17	0.22	40.00	23.33	13.33	23.30		23.97
Futura	1.07	0.05	93.33	6.66				0.67
Santana	1.83	0.22	60.00	16.67	3.33	20.00		17.00
Samanta	1.77	0.19	63.33		33.33	3.33		15.66
Ornella	1.53	0.13	60.00	26.67	13.33			8.00
Agria	1.13	0.06	86.67	13.33				1.33
JAN A 87 193 39	1.77	0.21	63.33	13.33	6.66		16.67	20.66
Granola	1.40	0.13	70.00	23.33	3.33	3.33		5.99
VDW 94-76	1.50	0.13	60.00	33.33	10.00	3.33		9.66
Viola	1.83	0.22	60.00	16.67	3.33	20.00		17.00
Santé	1.83	0.17	50.00	16.67	33.33			15.00
YP 91-123	1.30	0.12	80.00	10.00	10.00			5.00
Carmona	1.20	0.09	83.33	13.33	3.33			2.66
Ramos	1.33	0.13	76.67	16.67	3.33	3.33		5.33
Annabelle	1.23	0.08	76.67	23.30				2.33
Impala	1.23	0.11	83.33	13.33		3.33		3.66
Karin	2.27	0.24	36.67	10.00	43.33	10.00		25.33
Inova	1.13	0.06	86.67	13.33				1.33
Adora	1.17	0.07	83.33	16.67				1.67
Kornelie	1.67	0.15	53.33	26.67	20.00			10.67
Tomensa	1.27	0.10	76.67	20.00	33.33			15.33
Kreta	1.70	0.17	56.67	20.00	20.00	3.33		12.33
Mean	1.59							11.14
SD	0.48							9.31
VC	30.37							83.58

Table 4. Resistance of selected potato genotypes to blackspot bruise in 2003

Variety	Mean *ES*	Mean *SE*	*ES*					Blackspot index
			1	2	3	4	5	
Monika	2.67	0.24	33.33	6.66	20.00	40.00		36.67
YP 94-067	2.00	0.19	43.33	20.00	33.33		3.33	18.66
Westamyl	2.07	0.18	46.67	3.33	46.67	3.33		21.33
BEE J 85 113 54	2.70	0.24	23.30	10.00	40.00	26.67		35.67
Futura	1.60	0.03	70.00	10.00	10.00	10.00		12.00
Santana	1.87	0.23	53.33	20.00	13.33	13.33		16.66
Samanta	2.43	0.12	23.30	26.67	33.33	16.67		27.67
Ornella	2.00	0.15	53.33	10.00	23.30	10.00	3.33	20.65
Agria	1.43	0.08	70.00	16.67	13.33			7.00
JAN A 87 193 39	2.03	0.15	46.67	23.33	13.33	13.33	3.33	20.32
Granola	1.63	0.11	63.30	13.33	20.00	3.33		11.66
VDW 94-76	1.27	0.10	80.00	13.33	6.66			3.99
Viola	1.97	0.21	36.67	30.00	33.33			16.33
Santé	1.77	0.14	36.67	50.00	13.33			10.33
YP 91-123	1.37	0.10	76.67	10.00	13.33			6.33
Carmona	1.37	0.08	73.33	16.67	10.00			5.67
Ramos	2.60	0.15	30.00	13.33	26.67	26.67	3.33	34.00
Annabelle	1.40	0.09	66.67	30.00		3.33		5.33
Impala	1.47	0.10	66.67	20.00	13.33			7.33
Karin	2.27	0.19	33.33	6.66	60.00			24.67
Inova	1.60	0.13	70.00	10.00	10.00	10.00		12.00
Adora	1.67	0.06	60.00	16.67	20.00	3.33		12.00
Kornelie	2.20	0.13	30.00	23.33	43.33	3.33		21.99
Tomensa	1.60	0.17	63.33	16.67	16.67	3.33		10.67
Kreta	1.57	0.19	66.67	13.33	16.67	3.33		10.33
Mean	1.86							16.37
SD	0.43							9.64
VC	23.03							58.91

– water regime and storage. The effect of storage was indirectly proven also in this study, since for genotypes of the harvest 2003 decreased resistance to blackspot bruise was recorded; it could be explained by a longer storage period, during that the content of chlorogenic acid increases and it significantly correlates with discoloration (Delgado et al. 2001b). Corsini et al. (1999) also confirmed this fact in their study, when they found samples with decreased discoloration potential prior to harvest in the latter half of August compared to samples at harvest in the middle of September. They found the most susceptible samples in February.

The value of relation between years characterized by the correlation coefficient is 0.777** for the year 2001 and 2002, 0.448* for the year 2001 and 2003 and 0.426* for the year 2002 and 2003. Correlation analysis showed a relationship between ecological conditions of individual years and blackspot bruise. From values of correlation coefficients characterizing a relation between years it is resulted that the coefficient of heritability

Table 5. Scale for evaluation of potato genotype (genetic resource) resistance to blackspot bruise with addition of classification of tested potato varieties and hybrids

Evaluation scale			Variety, hybrids (mean *ES*)
ES	word expression of resistance	value of mean blackspot bruise index	
9	very high	0.00	
8	high to very high	0.01–5.00	Carmona (3.55) Agria (3.67) Annabelle (3.89) Futura (4.33) Impala (4.88) YP 91-123 (5.00) Adora (5.00)
7	high	5.01–10.00	VDW 94-76 (6.33) Granola (7.66) Inova (8.55)
6	medium to high	10.01–15.00	Kréta (12.00) Ornella (13.22) YP 94-067 (13.33) Kornelie (13.55) Santé (13.78) Tomensa (14.56)
5	medium	15.01–20.00	JAN A 87 193 39 (15.33) Ramos (16.67) Samanta (16.78) Santana (19.67)
4	low to medium	20.01–25.00	Viola (20.11) Monika (21.22)
3	low	25.01–30.00	Karin (25.67) BEE J 85 113 54 (26.10)
2	very low to low	30.01–35.00	Westamyl (31.67)
1	very low	over 35.00	

of this character ranged between 0.42 and 0.77. Pavek et al. (1993) found 0.85 for heritability of this character, confirming that breeding for resistance to blackspot bruise is successful using resistant parents with backcross potential. For more reliable testing of heritability of this character a repeated evaluation will be needed. Although even high variability was recorded for evaluated character within the evaluated set of tubers of several samples, genotypes with very good level of observed parameter and even low variability in its expression (modification variability) are present in the evaluated set.

Based on the results of the evaluation a scale was designed for the evaluation of potato genotype (genetic resource) resistance to blackspot bruise (Table 5). Varieties and hybrids included in the new designed scale in the scores 7 – high up to 9 – very high resistance could be regarded as suitable genetic resources in breeding for the improvement of the character. In the evaluated set there are varieties and hybrids: Carmona, Agria, Annabelle, Futura,

Table 6. Statistically significant differences among varieties and hybrids (**α = 0.01, *α = 0.05)

Variety, hybrid (mean blackspot index)	Carmona (3.55)	Agria (3.67)	Annabelle (3.89)	Futura (4.33)	Impala (4.88)	YP 91-123 (5.00)	Adora (5.00)	VDW 94-76 (6.33)	Granola (7.66)	Inova (8.55)	Karin (25.67)	BEE J 85 113 54 (26.10)	Westamyl (31.67)
Carmona (3.55)											*	*	**
Agria (3.67)											*	*	**
Annabelle (3.89)											*	*	**
Futura (4.33)											*	*	**
Impala (4.88)											*	*	**
YP 91-123 (5.00)											*	*	**
Adora (5.00)											*	*	**
VDW 94-76 (6.33)												*	**
Granola (7.66)													**
Inova (8.55)													**
Karin (25.67)	*	*	*	*	*	*	*						
BEE J 85 113 54 (26.10)	*	*	*	*	*	*	*	*					
Westamyl (31.67)	**	**	**	**	**	**	**	**	**	**			

Impala, YP 91-123, Adora, VDW 94-76, Granola and Inova. A very good level of resistance to blackspot bruise is found in hybrid YP 91-123 and the variety Annabelle, Carmona associated with a low variability of expression – modification variability (Table 1). These varieties and hybrids (Table 6) also have statistically significant differences of mean indexes of blackspot bruise involved in the evaluation scores 2 (very low to low resistance) and 3 (low resistance).

Acknowledgement

The authors wish to thank Helena Součková for English translation.

REFERENCES

Brown C.R., McNabnay M., Dean B. (1999): Genetic chracterization of reduced melanin formation in tuber tissue of *Solanum hjertingii* and hybrids with cultivated diploids. American Journal of Potato Research, *76*: 37–43.

Corsini D., Stark J., Thornton M.: Factors contributing to the blackspot bruise potential of Idaho potato fields. American Journal of Potato Research, *76*: 221–226.

Dale M.F.B., Mackay G.R. (1994): Inheritance of table and processing quality. In: Bradshaw J.E., Mackay G.R.: Potato genetics. CAB International.

Delgado E., Poberezny J., Pawelzik E. (2001a): Comparison of two methods for determining the discoloration potential of potato tubers based on their chemical and biochemical properties. American Journal of Potato Research, *78*: 389–394.

Delgado E., Sulaimen M.I., Pawelzik E. (2001b): Importance of chlorogenic acid on the oxidative potential of potato tubers of two German cultivars. Potato Research, *44*: 207–218.

Gall H. (1994): Hinweise zum Einsatz des elektro/nischen Pendelschlangwerkes MIDAS 88 P in der Sortenprufung und Forschung bei Kartoffeln. Senzorik/Entwicklung und Applikation, 01, 10.

Hamouz K., Lachman V., Pivec M., Orsák M. (1997): Vliv podmínek pěstování na obsah polyfenolických látek v bramborách u odrůd Agria a Karin. Rostlinná Výroba, *43*: 541–546.

Molema G.J. (1999): Mechanical force and subcutaneous tissue discoloration in potato. [PhD Thesis.] Published by the Institute of Agricultural and Environmental Engineering (IMAG), Wageningen, The Netherlands: 1–11.

Pavek J.J., Brown C.R., Martin M.W., Corsini D.L. (1993): Inheritance of blackspot bruise resistance in potato. American Journal of Potato Research, *70*: 43–48.

Received on September 30, 2004

ABSTRAKT

Metoda hodnocení odolnosti genotypů bramboru k abiotickému šednutí

V letech 2001 až 2003 byla ověřována metoda hodnocení odolnosti genotypů (genetických zdrojů) bramboru vůči abiotickému šednutí dužniny. Testováno bylo 30 hlíz od 25 odrůd a kříženců *Solanum tuberosum* L. pomocí elektronického úderného kyvadla MIDAS 88P. Analýza variance potvrdila existenci významných diferencí jak mezi jednotlivými odrůdami a kříženci, tak mezi ročníky. Byla stanovena bonitační stupnice pro hodnocení odolnosti genotypů (genetických zdrojů) bramboru vůči šednutí dužniny. Za vhodné genetické zdroje při šlechtění na zlepšení úrovně tohoto znaku lze považovat odrůdy a křížence zařazené v nově navržené bonitační stupnici do bonitačních stupňů 7 (vysoká) až 9 (velmi vysoká odolnost). V hodnoceném souboru jsou to tyto odrůdy: Carmona, Agria, Annabelle, Futura, Impala, Adora, Granola a Inova a kříženec: YP 91-123 a VDW 94-76.

Klíčová slova: brambor; *Solanum tuberosum* L.; abiotické šednutí dužniny bramboru; úderné kyvadlo; genotypy bramboru; genetické zdroje bramboru

Corresponding author:

Ing. Jaroslava Domkářová, Ph.D., Výzkumný ústav bramborářský, Dobrovského 2366, 580 01 Havlíčkův Brod, Česká republika
phone: + 420 569 466 227, fax: + 420 569 421 578, e-mail: domkarova@vubhb.cz