

Kalkaska: A Round White Chip-Processing Potato Variety with Common Scab Resistance

D. S. Douches · J. Coombs · R. Hammerschmidt ·
W. W. Kirk · C. Long

Published online: 19 May 2009
© Potato Association of America 2009

Abstract Kalkaska is a high yielding, round white potato with an attractive appearance with shallow eyes. Kalkaska has a vigorous vine and a late maturity. This variety has resistance to *Streptomyces scabies* Thaxter (common scab of potato) similar to Pike. Kalkaska has industry approved chip-processing storage characteristics (light color and low incidence of defects) and it also has better tolerance to blackspot bruise than Snowden. Specific gravity in Michigan averages 1.083, ranging from 1.075 to 1.096. Kalkaska also has a higher marketable yield than Pike and does not express heat necrosis in the tubers. The name Kalkaska was chosen to acknowledge a town located in the Michigan seed growing region.

Resumen Kalkaska es una papa de alto rendimiento, redonda blanca con un aspecto atractivo con ojos superficiales. Kalkaska tiene una planta vigorosa y una madurez tardía. Esta variedad tiene resistencia a *Streptomyces scabies* Thaxter (roña común de la papa), similar a Pike. Kalkaska tiene características de almacenamiento para el procesamiento de hojuelas fritas (color claro y baja incidencia de defectos) aprobadas por la industria, y también tiene una mejor tolerancia a la mancha negra por magulladura que Snowden. La gravedad específica en Michigan promedió 1.083, con un rango de 1.075 hasta 1.096. Kalkaska también tiene un rendimiento comercial mayor que Pike y no expresa necrosis debido al calor en

tubérculos. El nombre Kalkaska fue elegido para reconocer una ciudad situada en la región de producción de semilla en Michigan.

Keywords *Solanum tuberosum* · Cultivar ·
Streptomyces scabies

Background

Kalkaska is a new round white potato variety (*Solanum tuberosum* L.) developed at Michigan State University for chip-processing markets. Kalkaska was evaluated as seedling number MSJ036-A. It is a selection from a cross made in 1997 between the USDA/ARS-Beltsville, MD breeding line B1254-1 and a chip-processing breeding line S440 (Thill 1994) from the University of Wisconsin for the purpose of breeding scab-resistant chip-processing varieties. The pedigree of Kalkaska is described in Fig. 1. Kalkaska was named after a town in the Michigan seed potato growing region.

Kalkaska is a round white chip-processing variety with a medium set of uniform tubers (Fig. 2). The tubers have a low level of internal defects. Kalkaska has a vigorous vine with a 140 day maturity. The strengths of this variety is its resistance to common scab, combined with high yield potential and chip-processing quality across many environments. Agronomic trials were conducted at the Michigan State University research farms and on-farm grower trials. Kalkaska also has a higher marketable yield than Pike and does not express heat necrosis in the tubers.

The seedling generation was grown in 1998, followed by 2 years of selection and seed multiplication at the Lake City Experiment Station, Lake City, MI. Seed increase was located at the Lake City Experiment Station. Since 2002,

D. S. Douches (✉) · J. Coombs · C. Long
Dept. of Crop and Soil Sciences, Michigan State University,
E. Lansing, MI 48824, USA
e-mail: douchesd@msu.edu

R. Hammerschmidt · W. W. Kirk
Dept. of Plant Pathology, Michigan State University,
E. Lansing, MI 48824, USA

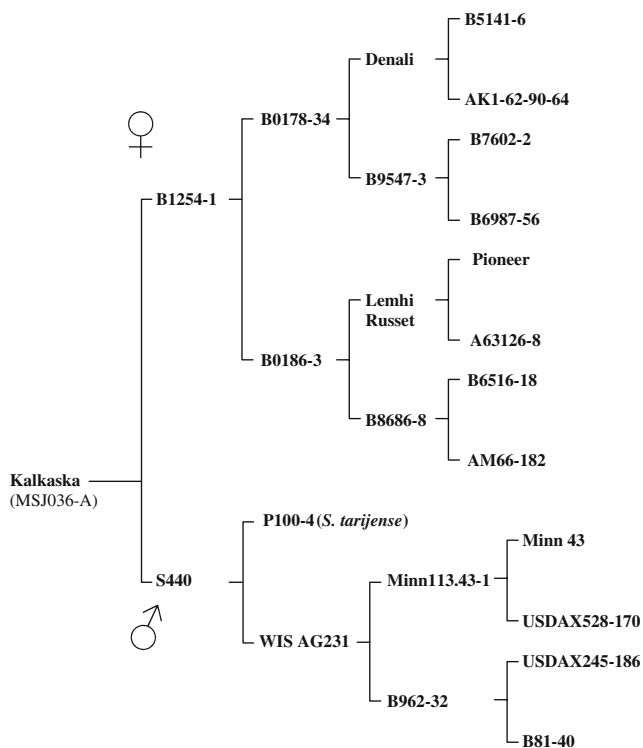


Fig. 1 Pedigree of Kalkaska (MSJ036-A)

Kalkaska has been tested in replicated agronomic trials at the Montcalm Research Farm, Entrican, MI, and in the scab nursery at the Michigan State University Soils Farm, East Lansing, MI. In 2004, it was entered into on-farm trials in Michigan with commercial growers. In 2006, Kalkaska was placed into commercial seed production.

Varietal Description

Plant Vine and Foliage Growth habit: Medium to tall height, semi-erect with a balance between stems and foliage visible. **Stems:** Weak stem anthocyanin coloration, wings are weak. **Leaves:** Medium-green (Royal Horticulture Society (R.H.S.) Color Chart value 147A) with sparse, short pubescence; medium leaf silhouette; petiole anthocyanin coloration is weak; leaf stipules are medium sized. **Terminal leaflets:** Broadly ovate with acuminate tip and lobed base, with slight leaflet margin waviness. **Primary leaflets:** Four to six pairs per leaf, medium ovate leaf shape, with acuminate tip and lobed base. **Secondary and tertiary leaflets:** ten pairs (range 5–12). **Vine maturity:** late (140 days).

Inflorescence Eleven to 30 with an average of 22 per plant; mean of 15 florets per inflorescence. **Corolla:** Pentagonal shape with a white color (R.H.S. Color Chart value 157A).

Calyx: Anthocyanin coloration is absent. **Anthers:** Narrow cone shape with a yellow-orange color (R.H.S. Color Chart value 14A). **Stigma:** Capitata and green (R.H.S. Color Chart value 137C). **Fertility:** Pollen shed is slight and female fertility is average, but Kalkaska can successfully be used as a male and female in crosses. Fruit set in the field is moderate.

Tubers Shape: Round. The average tuber length x width x thickness is 69 mm×72 mm×55 mm with an average weight of 203 g. **Skin:** Buff with a brown color (R.H.S. Color Chart value 164B). **Eyes:** Shallow eye depth, evenly distributed with an average 11 eyes/tuber; eyebrows have a slight prominence. **Flesh:** White (R.H.S. Color Chart value 11D). **Dormancy:** Medium, comparable to Atlantic.

Agronomic Production

Field experiments were conducted at the Montcalm Research Farm in Entrican, MI, a central Michigan site on a sandy loam soil representative of commercial irrigated potato production. Agronomic trials were conducted to measure total and marketable yields, determine tuber size distribution, specific gravity, blackspot bruising, evaluate tuber appearance, and incidence of external and internal defects. Kalkaska, other potato genotypes and other lines and check varieties were planted in a randomized complete block design with four replicates of 7.0 m (23 ft) plots. Kalkaska's agronomic performance has been tested for 6 years at the Montcalm Research Farm and 5 years in on-farm trials in Michigan. Six years (2003–2008) of full season (124–152 days after planting) agronomic data at the Michigan State University Montcalm Research Farm for Kalkaska in comparison to Pike and Snowden are summarized in Table 1. The yield of marketable tubers for Kalkaska was equivalent to or better than Snowden and superior to Pike. Also, the incidence of internal defects (hollow heart, internal brown spot and vascular discoloration) in oversize tubers for Kalkaska was less on average than Pike and Snowden. The specific gravity and vine maturity for Kalkaska was equivalent to Snowden and Pike. The agronomic performance for the Michigan on-farm trials was summarized in Table 2. Kalkaska had a marketable yield similar to Pike and Snowden in these trials. The specific gravity for Kalkaska was also equivalent to Snowden and Pike in the on-farm trials.

Chip-processing quality of Kalkaska was assessed on tubers from Montcalm Research Farm trials, Michigan on-farm trials, and from samples placed in the Michigan Potato Industry Commission's Dr. B.F. (Burt) Cargill Demonstration Storage. Tables 1 and 2 also make comparisons of

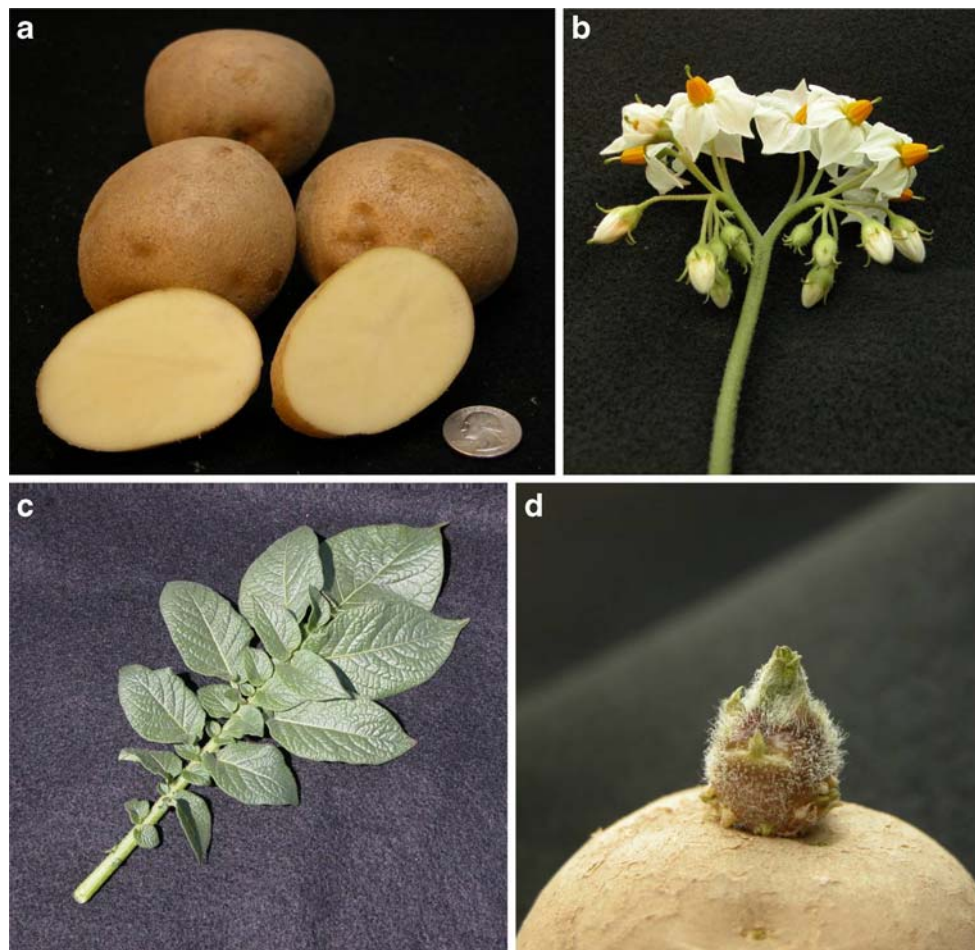


Fig. 2 Tuber (a), flower (b), leaf samples (c) and light sprouts (d) of Kalkaska

chip-processing quality of Kalkaska to Pike and Snowden from 2003–2008 from the Montcalm Research Farm trials. The out-of-the-field chip-processing results were acceptable for Kalkaska, Snowden and Pike. Tuber samples were also stored at 12°C in the Michigan Potato Industry Commission’s Commercial Demonstration Storage in Montcalm, Michigan. Tubers were sampled at about 2 week intervals and evaluated for chip quality and sugar analysis. The chip color scores for Kalkaska and Snowden for 2004–2008 are shown in Table 3. Sugar profile data for percent sucrose and glucose of the same samples are shown in Fig. 3. Chip color and sugar profile analysis of the Demonstration Storage samples were conducted by Techmark, Inc. (Lansing, MI). In these evaluations, the chip color of Kalkaska was acceptable throughout the storage season.

To evaluate blackspot bruise, tuber samples from Kalkaska, Pike and Snowden were collected at the time of grading for a simulated bruise test; data from 2003–2008 are shown in Table 4. The bruise data are presented in two ways: percentage of bruise-free potatoes and average number of bruises per tuber. Bruising levels of greater than

1.5 bruises per tuber and less than 20% bruise free are classified as very sensitive to black spot bruising during handling. The bruise reaction of Atlantic and Snowden is classified as sensitive. Kalkaska is classified as having similar blackspot bruise sensitivity as Pike and better than Snowden.

Disease Resistance

Replicated field trials were conducted at the MSU Soils Farm Scab Disease Nursery in East Lansing, Michigan to assess resistance to common scab (*Streptomyces scabies*). Based upon 6 years of trials, Kalkaska has a scab incidence ratings that is comparable to Pike and significantly less than Atlantic and Snowden (Table 5).

Kalkaska was also evaluated for foliar susceptibility to late blight (*Phytophthora infestans*). Although resistance was not observed, susceptibility was similar to other varieties such as Snowden and Pike which are considered moderately susceptible (data not shown). Kalkaska does

Table 1 Summary of full season agronomic performance trials at the Michigan State University Montcalm Research Farm, Entrican, Michigan 2003–2008

Entry	mt ha ⁻¹		Percent of total ^a					Specific gravity	Chip score ^b	Tuber quality (%) ^c				Maturity ^d
	US#1	Total	US#1	Bs	As	OV	PO			HH	VD	IBS	BC	
2003 (14 May–15 September; 124 d)														
Kalkaska	43.6	47.5	92	8	81	10	0	1.083	1.0	15	5	3	3	3.0
Pike	22.8	25.1	91	9	91	0	0	1.086	1.0	0	0	0	0	3.3
Snowden	31.1	33.1	94	6	86	8	0	1.087	1.0	38	13	0	0	3.3
LSD _{0.05}	6.8	7.1						0.003						
2004 (3 May–20 September; 140 d)														
Kalkaska	40.6	43.2	94	6	86	8	0	1.096	1.0	18	5	0	0	3.3
Pike	25.0	28.0	90	9	89	1	1	1.099	1.0	0	5	0	0	4.5
Snowden	29.5	32.7	90	8	87	4	2	1.097	1.0	3	25	0	0	3.5
LSD _{0.05}	5.4	5.3						0.004						
2005 (4 May–27 September; 147 d)														
Kalkaska	32.0	37.3	86	14	85	0	0	1.080	1.0	5	0	0	0	2.0
Pike	24.6	29.2	84	16	84	0	0	1.081	1.0	0	0	0	0	2.0
Snowden	37.9	42.0	90	10	86	4	0	1.081	1.0	28	8	0	0	2.5
LSD _{0.05}	7.6	7.7						0.003						
2006 (8 May–6 October; 152 d)														
Kalkaska	35.5	43.8	81	19	80	1	0	1.078	2.0	0	18	3	0	2.5
Pike	18.5	24.0	77	23	77	0	0	1.083	2.0	3	33	0	0	3.0
Snowden	28.9	35.7	81	18	77	4	1	1.081	2.0	10	48	5	0	2.5
LSD _{0.05}	5.6	5.4						0.004						
2007 (8 May–25 September; 141 d)														
Kalkaska	42.9	47.3	91	9	86	5	0	1.075	1.0	5	8	3	3	2.8
Pike	29.2	33.1	88	12	87	2	0	1.076	1.0	0	10	0	0	2.0
Snowden	40.2	44.0	91	9	79	12	0	1.072	1.0	30	27	0	0	2.0
LSD _{0.05}	7.7	8.0						0.003						
2008 (8 May–24 September; 140 d)														
Kalkaska	48.5	54.8	89	11	82	6	1	1.084	1.0	8	8	0	3	3.3
Pike	28.6	34.2	84	16	82	2	0	1.087	1.0	0	30	0	0	3.5
Snowden	40.3	46.5	87	13	83	3	1	1.088	1.0	15	33	0	3	3.8
LSD _{0.05}	7.9	7.5						0.004						
Mean (2003–2008)														
Kalkaska	40.5	45.7	89	11	83	5	0	1.083	1.2	8	7	1	1	2.8
Pike	24.8	28.9	86	14	85	1	0	1.085	1.2	0	13	0	0	3.1
Snowden	34.6	39.0	89	11	83	6	1	1.084	1.2	20	25	1	0	2.9

Mean comparisons were done using Fisher's Least Significant Difference ($\alpha=0.05$).

The plots were 7 m in length and spacing between plants was 30.5 cm. Inter-row spacing was 86.4 cm. Total nitrogen fertilization during the season was 200 kg/ha. The Montcalm site is a McBride sandy loam soil with supplemental overhead irrigation

^a Size Distribution: B: < 5.1 cm, A: 5.1–8.3 cm, OV: > 8.3 cm, PO pickouts

^b Snack Food Association Chip Score Ratings 1–5; 1 = Excellent; 5 = Poor; ≥ 2.5 = Unacceptable

^c Tuber Quality: HH hollow heart, VD vascular discoloration; IBS internal brown spot; BC brown center. Percent of 40 oversize (>8.3 cm) tubers cut

^d Vine maturity taken at late August. 1 = Early (vines completely dead), 5 = Late (flowering)

Table 2 Agronomic performance of Kalkaska compared to Pike and Snowden from Michigan On-Farm trials 2005–2008

Entry	mt ha ⁻¹		Percent of Total ^b					Specific gravity	Chip score ^c	Tuber quality (%) ^d			
	US#1	Total	US#1	Bs	As	OV	PO			HH	VD	IBS	BC
Kalkaska													
2005	52.9	58.1	91	9	88	2	0	1.077	1.8	0	0	23	3
2006	40.7	44.5	92	8	87	5	0	1.073	1.3	3	17	27	0
2007	32.8	38.2	86	10	84	2	4	1.076	1.0	3	13	0	0
2008	48.1	51.4	93	7	92	1	0	1.080	1.5	3	17	0	0
Mean ^a	43.6	48.0	90	9	88	2	1	1.076	1.4	3	12	13	1
Pike													
2005	41.4	45.9	91	9	86	5	1	1.076	1.5	7	0	10	0
2006	37.1	40.2	92	7	83	9	1	1.079	1.0	0	17	13	0
2007	29.1	33.8	84	10	82	1	7	1.076	1.0	0	27	0	0
2008	49.4	52.1	94	6	84	10	0	1.081	1.2	10	3	27	0
Mean	39.2	43.0	90	8	84	6	2	1.078	1.2	4	12	13	0
Snowden													
2005	56.2	59.7	94	5	84	10	0	1.077	1.3	13	20	17	0
2006	46.7	49.4	94	6	84	10	0	1.074	1.3	3	53	7	0
2007	41.4	44.0	92	3	81	11	5	1.074	1.0	3	40	0	3
2008	46.9	50.3	93	7	89	4	0	1.077	1.0	0	33	3	0
Mean	47.8	50.8	93	5	85	9	1	1.075	1.2	5	37	7	1
Overall on-farm mean													
Kalkaska	43.6	48.0	90	9	88	2	1	1.076	1.4	3	12	13	1
Pike	39.2	43.0	90	8	84	6	2	1.078	1.2	4	12	13	0
Snowden	47.8	50.8	93	5	85	9	1	1.075	1.2	5	37	7	1
LSD _{0.05}	NS	NS						NS					

Mean comparisons were done using Fisher's Least Significant Difference ($\alpha=0.05$)

^a Mean of three on-farm locations (Allegan, Monroe, and Montcalm counties) contributing to annual mean

^b Size distribution: B: < 5.1 cm, A: 5.1–8.3 cm, OV: > 8.3 cm, PO pickouts

^c Snack Food Association Chip Score; 1 = Excellent; 5 = Poor; ≥ 2.5 = Unacceptable

^d Tuber quality: HH hollow heart, VD vascular discoloration; IBS internal brown spot; BC brown center. Percent of 40 oversize (>8.3 cm) tubers cut

express PLRV and mosaic symptoms, but it has not been formally tested for its level of susceptibility. Observations during field seed increase or during agronomic trials did not indicate any unusual susceptibility to PVX, PVY and PLRV. Kalkaska had shown some tolerance to potato early die in field trials at the Montcalm Research Farm (Bird 2005).

Electrophoretic Patterns

Leaf and tuber tissue were sampled from Kalkaska to construct an electrophoretic fingerprint. The procedures and allelic designations used are according to Douches and Ludlam (1991). The transcript for seven enzyme loci is described as: *Mdh-1²1²1²1³*, *Mdh-2²2²2²2²*, *Pgi-1²1²1²1²*, *Got-1³1³1⁴1⁴*, *Got-2¹2³2³2⁵*, *Pgm-1²1²1³1³*, *Pgm-2²2²2²2³*.

This electrophoretic data is maintained as part of a database with over 250 lines and varieties. The electrophoretic fingerprint is unique to Kalkaska.

Chemistry

Total tuber glycoalkaloids (TGA) were measured on tubers collected at harvest from 2005–2006. These samples were analyzed by Brian Perkins at the University of Maine. TGA analyses, solid phase/ ion pairing extraction and rapid high-performance liquid chromatographic (HPLC) determination method was used (Carman et al. 1986). In each year, the level of TGA was within the acceptable range for Kalkaska (17.2–17.2 mg TGA/100 g fresh weight), Atlantic (8.4–11.6 mg TGA/100 g fresh weight), and Snowden (16.1–17.8 mg TGA/100 g fresh weight).

Table 3 Chip color and sugar profile results for Kalkaska and Snowden at the Michigan potato industry commission B.F. Burt Cargill demonstration storage, Entrican, MI 2004–2008

Line	Chip color ^a sample dates:															
2004–2005:	10/5/2004	10/19/2004	11/2/2004	11/16/2004	11/30/2004	12/28/2004	1/25/2005	2/22/2005	3/9/2005	3/22/2005	4/5/2005					
Temp (°C)	14.6	-	14.4	13.1	13.6	13.1	12.8	13.1	13.0	13.0	13.0	13.0				
Kalkaska	2.0	1.5	1.5	1.5	1.0	1.5	1.0	1.5	1.5	1.5	2.0	2.0	-	-	-	-
Snowden	2.0	1.5	1.5	1.5	1.0	1.0	1.0	1.5	1.0	1.5	2.0	2.0	-	-	-	-
2005–2006:	11/1/2005	11/15/2005	11/29/2005	12/13/2005	12/28/2005	1/10/2006	1/24/2006	2/7/2006	2/21/2006	3/7/2006	3/21/2006	4/4/2006	4/18/2006			
Temp (°C)	13.0	12.6	12.4	12.4	12.2	12.2	12.2	12.0	12.0	11.7	11.7	12.3	11.7			
Kalkaska	1.5	1.0	1.0	1.0	1.0	1.0	1.0	1.0	2.0	1.5	1.5	1.5	2.0			
Snowden	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5	1.5	2.0			
2006–2007:	10/10/2006	11/6/2006	11/20/2006	12/4/2006	12/18/2006	1/15/2007	1/29/2007	2/12/2007	2/24/2007	3/12/2007	3/26/2007	4/9/2007	4/23/2007			
Temp (°C)	13.4	13.5	13.1	13.6	13.1	12.6	12.2	12.8	11.8	11.8	12.0	12.1	12.9			
Kalkaska	2.0	1.5	1.5	1.5	1.5	1.0	1.0	1.5	1.0	1.5	1.5	1.0	1.5			
Snowden	1.5	1.5	1.5	1.0	1.5	1.0	1.0	1.0	1.0	1.0	1.0	-	-			
2007–2008:	10/15/2007	10/29/2007	11/12/2007	11/26/2007	12/17/2007	1/7/2008	1/21/2008	2/4/2008	2/18/2008	3/3/2008	3/17/2008	3/31/2008	4/14/2008			
Temp (°C)	14.6	13.3	13.3	12.6	12.6	12.8	12.4	12.2	12.1	12.2	11.7	12.3	12.2			
Kalkaska	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0			
Snowden	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.5			

Chip color and sugar profile analysis were conducted by Techmark, Inc., Lansing, Michigan

^a Snack Food Association Chip Score; 1 = Excellent; 5 = Poor; ≥ 2.5 = Unacceptable

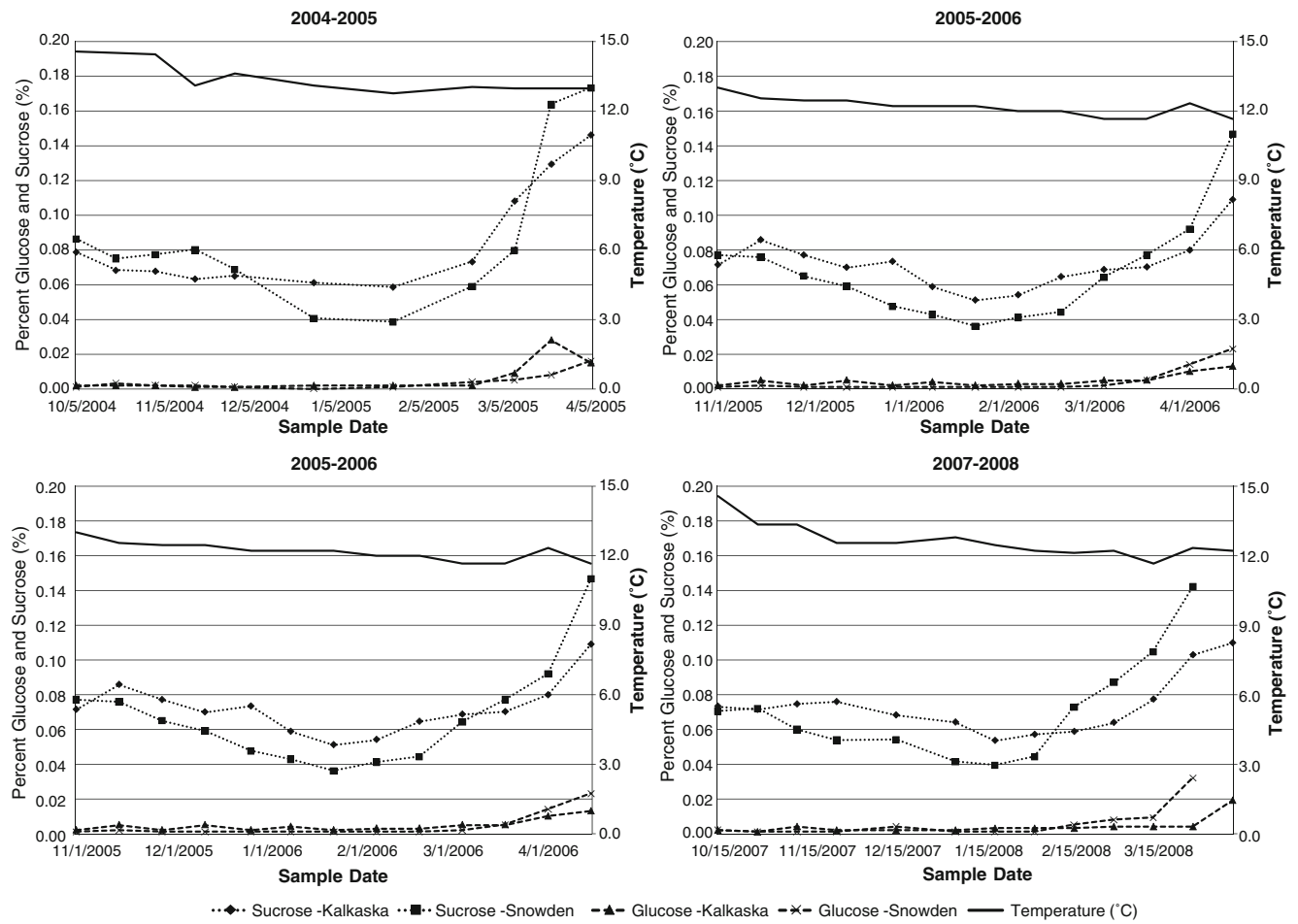


Fig. 3 Sugar profiles of Kalkaska and Snowden from the B. F. Burt Cargill Demonstration Storage

Table 4 Blackspot bruise susceptibility evaluations for Kalkaska, Pike, and Snowden from simulated bruise tests 2003–2008

Entry	Year	Number of spots per tuber						Percent (%) bruise free	Average spots/tuber
		0	1	2	3	4	5+		
Kalkaska	2003	11	7	3	3	1	0	44	1.0
Pike		21	1	3	0	0	0	84	0.3
Snowden		10	6	4	4	1	0	40	1.2
Kalkaska	2004	9	9	7	0	0	0	36	0.9
Pike		7	11	4	3	0	0	28	1.1
Snowden		3	7	6	8	1	0	12	1.9
Kalkaska	2005	17	6	2	0	0	0	68	0.4
Pike		17	6	0	2	0	0	68	0.5
Snowden		7	5	7	6	0	0	28	1.5
Kalkaska	2006	3	11	6	0	0	0	15	1.2
Pike		11	5	3	0	1	0	55	0.8
Snowden		4	8	2	5	0	0	21	1.4
Kalkaska	2007	13	3	4	4	1	0	52	1.1
Pike		13	5	7	0	0	0	52	0.8
Snowden		9	3	8	3	0	2	36	1.5
Kalkaska	2008	8	10	3	4	0	0	32	1.1
Pike		15	7	1	1	1	0	60	0.6
Snowden		4	4	7	8	2	0	16	2.0
Kalkaska	Mean	10	8	4	2	0	0	41	1.0
Pike		14	6	3	1	0	0	58	0.7
Snowden		6	6	6	6	1	0	26	1.6
LSD _{0.05}								20	0.4

Simulated blackspot bruise tests: Each 4-replicate composite sample of 25 A-size tubers were collected at harvest, held at 10°C (50°F) at least 12 h, and placed in a six-sided plywood drum and rotated ten times to produce simulated bruising. Samples were abrasive-peeled and scored

Mean comparisons were done using Fisher's Least Significant Difference ($\alpha=0.05$)

Seed Availability

Virus-free tissue culture plantlets of Kalkaska are maintained at the Michigan State University potato breeding and genetics program. Kalkaska was also sent to Sklarczyk Seed Farm (8714 M32 East, Johannesburg,

MI 49751, phone 989-731-5452) and Krueger Seed Farm (2797 W. Hawkes Hwy., Hawks, MI 49743, phone 989-734-7366). Seed is also available from Iott Seed Farms, Inc. (4637 Cool Rd., Kalkaska, MI 49646, phone 231-258-8294). Plant Variety Protection for Kalkaska is being sought.

Table 5 Summary of common scab (*Streptomyces scabies*) ratings from the scab disease nursery at the Michigan State University soils farm, East Lansing, MI 2003–2008

Entry	2003	2004	2005	2006	2007	2008	Mean
Kalkaska	1.3	0.8	0.8	1.2	0.8	1.1	1.0
Pike	1.5	0.9	1.0	1.4	1.4	1.4	1.3
Atlantic	2.3	2.1	1.6	2.8	2.4	2.4	2.3
Snowden	2.4	1.9	2.0	2.8	2.6	2.6	2.4
LSD _{0.05}	1.3	1.0	0.9	0.9	0.9	0.9	

MSU Scab Disease Nursery plot rating of 0–5; 0: No Infection; 1: Low Infection <5%, no pitted lesions; 3: Intermediate >20%, some pitted lesions (Susceptible, as commonly seen on Atlantic); 5: Highly Susceptible, >75% coverage and severe pitted lesions

Mean comparisons were done using Fisher's Least Significant Difference ($\alpha=0.05$)

Acknowledgements The development and testing of Kalkaska was supported in part by the Michigan Agricultural Experiment Station, Michigan Potato Industry Commission and the USDA Special Grant for Potato Breeding/Variety Development. All experiments comply with the current laws of the country in which they were performed.

References

- Bird, G. 2005. Evaluation of potato varieties and breeding lines for tolerance to early-die. *Michigan Potato Research Report* 37: 127–143.
- Carman, A.S.S.S., G.M.Ware Shia, O.J. Francis, and G.P. Kirschenheuter. 1986. Rapid high-performance liquid chromatographic determination of the potato glycoalkaloids α -solanine and α -chaconine. *Journal of Agricultural and Food Chemistry* 34: 279–282.
- Douches, D.S. and K. Ludlam. 1991. Electrophoretic characterization of North American potato varieties. *American Potato Journal* 68: 767–780.
- Thill, C. 1994. *An accelerated breeding method for developing cold (4°C) chipping potatoes; and the identification of superior parental clones*. Ph.D. Thesis, University of Wisconsin-Madison.