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Freedom Russet—A Dual Purpose Russet Potato Cultivar with Resistance to Common Scab and Good Fry Quality

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Abstract Freedom Russet was developed from a cross between ND14-1, a parent with scab resistance, and W1005rus, a parent with good processing quality. It is a mid-season cultivar and can be used for dual purposes for both fresh market and processing. The tubers of Freedom Russet are oblong-long with medium-dark russet skin, and have an attractive appearance. Freedom Russet tubers have better external and internal qualities than Russet Burbank tubers. The total and US No. 1 yield of Freedom Russet is equal to or higher than Russet Burbank in most environments. The specific gravity of Freedom Russet is similar or 1–3 unit less than Russet Burbank. Freedom Russet produced better fry color than Russet Burbank when processed after storage at 10, 8.9, and 7.2°C. It showed similar susceptibility to both early blight and late blight compared to Russet Burbank. Freedom Russet is resistant to common scab and moderately resistant to powdery scab. It is similarly susceptible to soft rot and pink rot as Russet Burbank, and clearly expresses bacterial ring rot symptoms. Freedom Russet is tolerant to Verticillium wilt and showed better yield potential than Russet Burbank under early dying pressure.

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Resumen Freedom Russet fue desarrollado a partir de un cruce entre ND14-1, un progenitor con resistencia a sarna, y W1005rus, un progenitor con buena calidad de procesamiento. Es un cultivar de estación media y se puede utilizar para doble propósito tanto para mercado fresco como para procesamiento. Los tubérculos de Freedom Russet son oblongo-largos con cáscara medianamente oscura rugosa, y tienen una apariencia atractiva. Los tubérculos de Freedom Russet tienen mejores cualidades externas e internas que los tubérculos de Russet Burbank. El rendimiento total y US No. 1 es igual o superior a Russet Burbank en la mayoría de los ambientes. La gravedad específica de Freedom Russet es similar o inferior en 1–3 unidad a Russet Burbank. Freedom Russet produce mejor color de hojuelas fritas que Russet Burbank cuando procesado tras el almacenamiento a 10, 8.9, y 7.2°C. Mostró susceptibilidad similar a ambos tizón temprano y tizón tardío en comparación con Russet Burbank. Freedom Russet es resistente a la sarna común y moderadamente resistente a la roña. Es igualmente susceptible a la pudrición blanda y pudrición rosada como Russet Burbank, y expresa claramente síntomas de pudrición bacterial anular. Freedom Russet es tolerante a la marchités por Verticillium y mostró mejor potencial de rendimiento que Russet Burbank ante presión de muerte prematura.

Keywords *Solanum tuberosum* L. · Fresh market · French fry

Introduction

Freedom Russet (W1836-3rus) has potential for dual use as a fresh market or processing cultivar. It was developed from a cross made in 1991 between ND14-1 and W1005rus (Fig. 1) at the Rhinelander Agricultural Research Station. The maternal parent ND14-1 was a russet line developed by

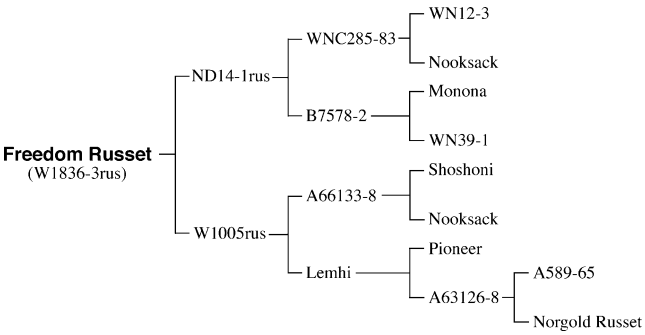

Fig. 1 Pedigree of Freedom Russet. WN12-3 and WN39-1 are breeding lines developed by the North Dakota State University (NDSU) potato breeding program

the potato breeding program at North Dakota State University. ND14-1 has a good appearance and is resistant to common scab. The paternal parent W1005rus was a russet line developed by the University of Wisconsin potato breeding program. W1005rus is known for its excellent processing quality. Freedom Russet was planted in the seedling stage in 1992, single-hill plots in 1993, four-hill plots in 1994, eight-hill plots in 1995, 20-hill plots in 1996, 40-hill plots in 1997, replicated trials at Hancock (120 day season) and Rhinelander (100 day season) from 1998 to 1999, in the Wisconsin State Trial at Hancock and Antigo from 2000 to 2002, and in the North Central Regional Trials (NCRT) from 2001 to 2003. Freedom Russet entered the tissue culture system of the Wisconsin Seed Potato Certification Program in the summer of 2002. It was released as a cultivar in 2004. The first foundation seed tubers were sold to Wisconsin seed growers in 2005. Freedom Russet was included in the Wisconsin Certified Seed Potato Directory in 2005 (14.2 ha), 2006 (23.9 ha), 2007 (43.3 ha), and 2008 (45.3 ha).

Description

Plant Vine and Foliage Characteristics

Haulm: Freedom Russet has semi-spreading growth habit, with an intermediate stem type. It is a mid-season cultivar with 120 days to maturation. Freedom Russet has a large sized and uniform canopy with robust vines (Fig. 2). *Stems*: Freedom Russet has 3 to 5 stems per plant. Stems have no anthocyanin coloration and low density of pubescence. It has a medium open silhouette, medium leaf stipule size, and large axillary shoots. *Terminal leaflets*: Elliptical

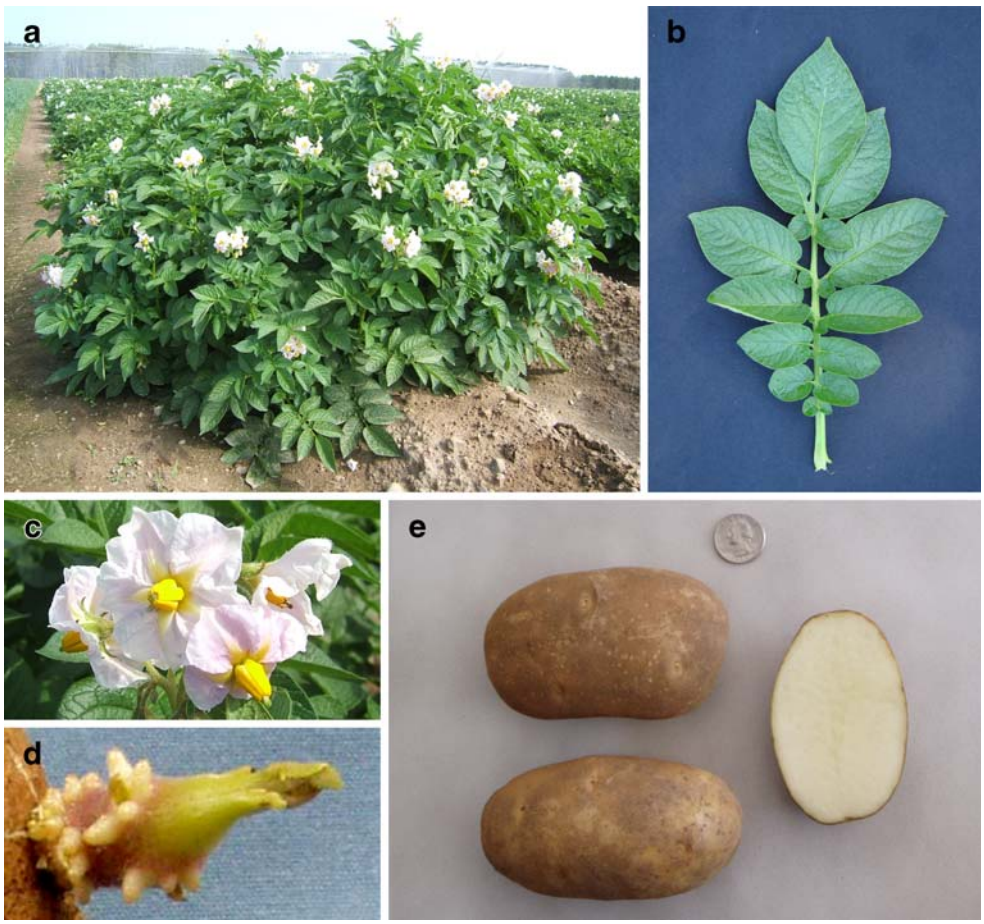

Fig. 2 Morphological characteristics of Freedom Russet variety. **a** Plant; **b** Leaf; **c** Flowers; and **d** Sprouts under diffused light; and **e** Tubers (the coin has a 2.5-cm diameter)

terminal leaflet shape with an acuminate tip, acute base shape, and no margin waviness. *Primary leaflets*: Primary leaflets are lanceolate and medium size, with four pairs of leaflets per leaf. *Secondary and tertiary leaflets*: Freedom Russet has four pairs of secondary and tertiary leaflets. *Petiole*: Petioles exhibit no anthocyanin coloration.

Flower Characteristics

Flowers: Freedom Russet has 3 to 7 inflorescences per plant and 6 to 11 flowers per inflorescence. *Calyx*: Calyx is devoid of anthocyanin coloration. *Corolla*: Corolla is in rotate shape with a pale purplish pink color (10 P 9/4 Munsell). *Stigma*: Stigmas are capitate, short above anthers, pale green (5 GY 6/10 Munsell). *Anthers*: Anthers have a broad cone and limited pollen but sufficient to be used as a male parent. *Berries*: Low frequency.

Tuber Characteristics

Tuber shape and size: The tubers of Freedom Russet are considered medium to large in size averaging 220 to 300 g. The tubers are blocky in shape and are more uniform than those of Russet Burbank (Fig. 2). Freedom Russet has an average of 8-12 tubers per plant. Mean tuber length is 98 mm ranging from 57 to 155 mm (standard deviation, SD, 19.6). Mean tuber width is 54 mm ranging from 40 to 76 mm (SD 6.5). Mean tuber thickness is 44 mm ranging from 33 to 58 mm (SD 4.9). *Indices*: Tuber length to width ratio is 1.81, length to thickness ratio is 2.22, and thickness to width ratio is 0.81. *Skin*: Tubers have a medium-dark russet skin (5 YR 4/4 Munsell), which is darker than Russet Burbank. *Flesh*: Pale yellow (2.5Y 8/4 Munsell). *Eyes*: Shallow and evenly distributed eyes. The mean number of eyes per tuber is 11 ranging from 8 to 14. *Sprouts under diffuse light*: Sprouts are in a round-ovoidal shape, weak pubescence on the sprout base, reddish-blue-violet sprout base with weak intensity of anthocyanin coloration (Fig. 2). The closed sprout tip shows no pubescence and a faint red-violet color. The sprouts have high frequency of sprout root initials, strong protrusion of lenticels, and short lateral shoots. *Physiological characteristics*: Freedom Russet has a tuber maturity similar to Russet Burbank, medium specific gravity, medium to long tuber dormancy.

Observations over time revealed that when Russet Burbank produced bottle-neck shaped tubers, pointed ends were observed in some tubers of Freedom Russet. Freedom Russet tubers generally show an overall smooth and marketable appearance. Lenticels were clearly observed at harvest in wet years prior to harvest, but became not evident when tubers dried out. Freedom Russet was ranked 1st or 2nd in tuber appearance out of 7 entries in the NCRT (entries included the standards Russet Norkotah and Russet Burbank) in Alberta, Manitoba, Michigan, Minnesota and Ontario in 2001; and was ranked 1st or 2nd out of 9 entries, in Michigan and Ontario in 2002, and was similarly ranked out of 11 entries in 2003 in Alberta, Manitoba, Michigan and Minnesota (Thill et al. 2002, 2003, 2004).

Freedom Russet tubers had a shorter dormancy period than Russet Burbank when the tubers were stored at 7.2°C with 85% relative humidity. Freedom Russet tubers showed a slow evolution from peeping to longer sprouts: an average of 147 days to peeping (1 mm long sprouts) and 178 days to reaching 1.3 cm long sprouts, vs. 181 and 209 days for Russet Burbank (Porter et al. 2002, 2003, 2005).

Agronomic Performance

The total and US No. 1 yields of Freedom Russet were higher than those of Russet Burbank and Russet Norkotah in the NCRT (Tables 1, and 2). Freedom Russet yields were highest in Minnesota, Wisconsin and Alberta (Thill et al. 2002, 2003, 2004). In the NCRT, the US No. 1 percentage (average from 2001–2003) of Freedom Russet (78.1%) was better than Russet Burbank (60.9%) and similar to Russet Norkotah (79.9%). In New York (Freeville site), the total yield of Freedom Russet in 2004 was similar to Russet Burbank, but higher than Shepody, Stampede Russet and Russet Norkotah, while the marketable yield was greater

Table 1 Total yield of Freedom Russet and standard cultivars in Hancock breeding trials (1998–99) and North Central Regional Trial (2001–03)[a]

Number of Trial Sites	Year	Total yield (t/ha)			Difference with	
		Freedom Russet	Russet Burbank	Russet Norkotah	Russet Burbank	Russet Norkotah
2	1998–99	49.8	44.2	43.4	5.6	6.4
10	2001	37.9	29.8	36.7	8.1	1.2
7	2002	45.8	43.8	39.2	2.0	6.6
10	2003	38.2	38.4	35.7	−0.2	2.5

[a] The North Central Regional Trial includes data from Alberta, Iowa, Manitoba, Michigan, Minnesota, Nebraska, North Dakota, Ontario, Wisconsin (irrigated) and North Dakota and Ohio (dry land)

Table 2 Marketable (US No. 1) yield of Freedom Russet and standard cultivars in Hancock breeding trials (1998–99) and North Central Regional Trial (2001–03)

Number of Trial Sites	Year	Marketable yield (t/ha)			Difference with	
		Freedom Russet	Russet Burbank	Russet Norkotah	Russet Burbank	Russet Norkotah
2	1998–99	45.2	35.2	41.2	10.0	4.0
10	2001	29.0	17.9	29.6	11.1	−0.6
7	2002	37.3	32.0	32.0	5.3	5.3
10	2003	29.4	24.7	28.7	4.7	0.7

Table 4 Specific gravity of Freedom Russet and standard cultivars in the North Central Regional Trial (2001–03)

Number of Trial Sites	Year	Specific gravity (×1000–1000)			Difference with	
		Freedom Russet	Russet Burbank	Russet Norkotah	Russet Burbank	Russet Norkotah
10	2001	78.7	77.4	73.0	1.3	5.7
6	2002	78.8	78.8	76.0	0.0	2.8
9	2003	76.5	76.0	70.5	0.5	6.0

than all of these varieties (Halseth et al. 2005). Five years of trial data in Presque Isle, Maine, showed a consistent trend of higher total yield and US No. 1 yield of Freedom Russet than Russet Burbank. It also consistently produced a lower percentage of culls than Russet Burbank (Porter et al. 2001, 2002, 2003, 2004, 2005).

Data from the Wisconsin Variety Trials in three locations over three years (Antigo, Hancock, and Spooner, 2001, 2002, 2003) showed that Freedom Russet had a higher proportion of tubers greater than 283.5 g (10 oz) compared to Russet Burbank. Approximately 55% of the Freedom Russet tubers were in the category from 170.1 g to over 453.6 g (6 oz to >16 oz) and 18.1% tubers in the category of 283.5–453.6 g (10–16 oz), vs. 42.7% and 12.1%, respectively, for Russet Burbank (Kostichka 2004). Freedom Russet tubers showed a comparable or higher proportion of the tubers free of external and internal defects than Russet Burbank (Table 3). The average specific gravity of Freedom Russet in the NCRT was similar to that of Russet Burbank (Table 4). The tendency for dry matter to be slightly lower than Russet Burbank, especially during stress conditions, is a weakness of Freedom Russet with regard to processing. However, this weakness may be partially overcome by the processing quality of the Freedom Russet tubers as discussed in the following sections.

Freedom Russet has medium to high yields producing more than 50 ton/ha under irrigated production in Central Wisconsin (Table 5). Freedom Russet yield was comparable to Russet Burbank during 2002 and 2003 trials at Hancock, Wisconsin. During heavy leaching and early dying pressure in 2004, Freedom Russet yielded more than Russet Burbank. Freedom Russet yields were similar comparing 30 and 41 cm in-row spacing across years, but were typically reduced at in-row spacing of 51 cm. Freedom Russet consistently had better US No. 1 yield than Russet Burbank, in large part due to lower cull rate and fewer undersized (<4.3 cm tuber diameter) tubers. Even though US No. 1 yields of Freedom Russet were higher than Russet Burbank, the proportion of cull potatoes was still greater than 10% due to the slightly rough shape of Freedom Russet. Uneven watering led to a knobby appearance or poor shape in Freedom Russet.

Freedom Russet also has a tuber size distribution within US No. 1 potatoes similar to or larger than Russet Burbank (Table 5). It has fewer tubers <4.3 cm in diameter than Russet Burbank consistently across years and in-row spacings. Proportion of US No. 1 tubers less than 168 g was lower for Freedom Russet compared to Russet Burbank. It also had a higher proportion of tubers greater than 168 g and 280 g compared to Russet Burbank. As such, Freedom Russet may produce a size profile more valuable for fresh market and processing compared to Russet Burbank. Freedom Russet yields and the tuber size

Table 3 Tuber quality of Freedom Russet and standard cultivars in Hancock breeding trials (1998–99) and North Central Regional Trial (2001–03)

Year	Free of external defects (%)				Free of internal defects (%)			
	Number of Trial Sites	Freedom Russet	Russet Burbank	Russet Norkotah	Number of Trial Sites	Freedom Russet	Russet Burbank	Russet Norkotah
1998–99	2	95.6	86.5	96.0	2	98.5	98.5	100.0
2001	7	94.4	77.0	90.6	9	92.9	88.0	91.3
2002	5	90.9	81.3	91.8	7	89.1	81.6	79.6
2003	7	92.3	74.3	94.1	8	91.9	81.4	93.3

Table 5 Influence of in-row spacing on yield and size distribution of Freedom Russet compared to Russet Burbank at Hancock, Wisconsin (2002–04)

Year	Variety	Spacing (cm)	Stems / plant	Tubers / plant	Yield (T/ha)				Size grade (% US No. 1 yield)					
					Total	US No. 1	Culls	<4.3 cm dia.	<112g	112–168g	168–280g	280–364g	364–454g	>454g
2002	Russet Burbank	30			58.8	37.2	9.3	12.2	27	37	31	5	0	0
		41			53.8	36.3	7.2	10.3	20	34	38	9	0	0
		51			50.2	31.7	8.1	10.5	19	30	43	9	0	0
	Freedom Russet	30			59.8	47.3	4.4	8.0	17	38	37	9	0	0
		41			47.4	37.0	5.2	5.3	13	32	42	13	0	0
		51			54.4	43.9	6.1	4.4	17	33	38	12	0	0
	LSD				4.7	4.7	1.5	1.5	6	6	NS	NS	NS	NS
2003	Russet Burbank	30	2.9	12.7	64.1	52.3	8.5	3.4	18	30	34	12	5	1
		41	3.2	15.8	60.2	51.4	6.7	2.1	13	26	39	13	6	3
		51	2.9	14.8	58.0	48.9	7.3	1.8	10	21	38	16	7	8
	Freedom Russet	30	3.4	13.2	58.2	51.9	3.9	2.4	10	26	46	12	5	2
		41	3.9	14.6	58.1	51.2	5.2	1.7	7	21	46	15	7	4
		51	3.9	14.8	48.1	42.8	3.8	1.3	9	22	42	16	8	3
	LSD		0.6	2.3	6.0	NS	NS	NS	NS	NS	NS	NS	NS	NS
2004	Russet Burbank	30	4.0	8.3	43.2	31.7	4.3	7.1	40	40	17	3	1	0
		41	4.1	5.4	42.0	30.8	4.4	6.9	32	40	23	4	2	0
		51	3.8	9.1	39.9	28.9	6.4	4.6	26	39	31	4	1	1
	Freedom Russet	30	4.2	6.7	50.8	44.7	3.0	2.9	23	41	29	5	2	1
		41	3.9	11.3	49.3	42.0	4.5	2.7	15	37	37	6	3	2
		51	5.4	13.7	49.2	41.8	4.9	2.5	14	37	37	8	4	1
	LSD		0.8	3.2	6.1	5.7	1.5	0.9	NS	NS	NS	NS	NS	NS

profile were optimized at in-row spacing of 35 cm or approximately 10 tubers per 3 m of potato row.

Freedom Russet produced more stems per plant than Russet Burbank during 2003 and 2004 (Table 5). It produced fewer tubers per plant compared to Russet Burbank in 2003 which likely promoted larger tuber size profile. In contrast, Freedom Russet produced more tubers per plant compared to Russet Burbank in 2004. It, however, maintained a larger tuber size profile compared to Russet Burbank. Freedom Russet emerged at a similar time compared to Russet Burbank across all years. However, its canopy development was slower than Russet Burbank (Fig. 3). Freedom Russet closed its canopy about 7 to 10 days later than Russet Burbank in different years.

Freedom Russet tuber bulking rates were similar to or greater than Russet Burbank in 2002 and 2003 (data not shown). In 2004, Freedom Russet tubers bulked later and more rapidly during late bulking than Russet Burbank potatoes (Fig. 4). Heavy rains leached nitrates and other nutrients from the plot area in 2004. Even though supplemental nitrogen was applied via fertirrigation, early dying led to early vine senescence and decreased tuber bulking in Russet Burbank. Freedom Russet appeared to tolerate early dying pressure better than Russet Burbank under the 2004 growing conditions.

Freedom Russet was not observed to be sensitive to metribuzin. Metribuzin herbicides applied postemergence at 425.7 g, 560.4 g and 1120.8 g a.i./ha caused no injury and did not affect yield (Binning et al. 2003). Freedom Russet total and US No. 1 yield was increased by maleic hydrazide applications (Sabba et al. 2008). Maleic hydrazide had the largest effect when applied to plants possessing tubers averaging 5 cm in diameter. Maleic hydrazide reduced the proportion of off-shape tubers thereby increasing the percentage and yield of US No. 1 tubers.

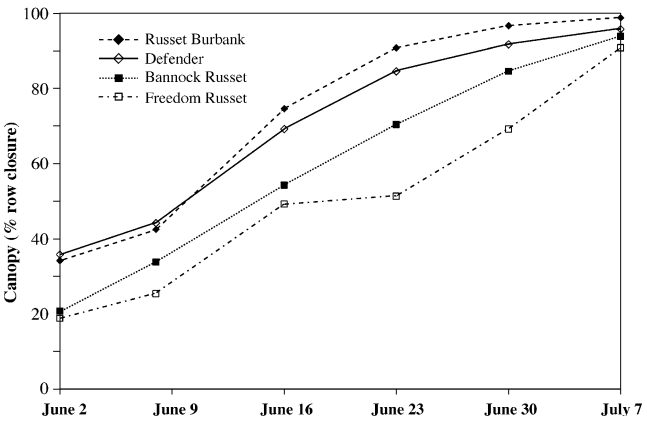

Fig. 3 Influence of variety on canopy cover in russet processing potatoes (Hancock, Wisconsin, 2004)

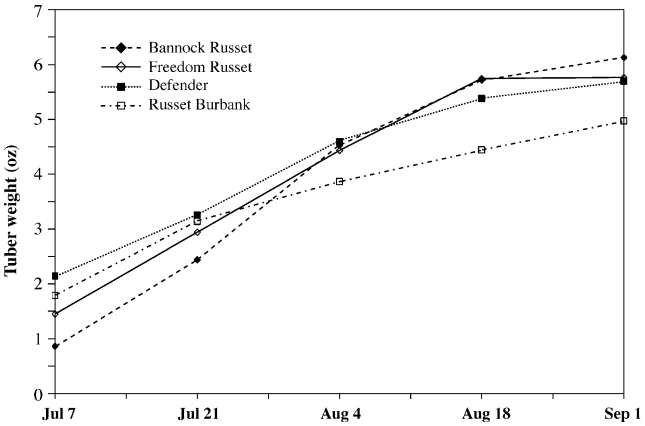

Fig. 4 Tuber bulking in russet processing potatoes (Hancock, Wisconsin, 2004)

Tuber Quality

Based on processing evaluations performed in the Red River Valley Laboratory (Potato Research Worksite in East Grand Forks, Minnesota) for the NCRT Freedom Russet had a fry color similar to or better than that of Russet Burbank when the tubers were processed at harvest (15.5°C) or after 3, 5 and 6 months of storage at 8.9°C (Table 6). Glynn and Sowokinos (2005) classified Freedom Russet and Umatilla in the same Class B group (acceptable fry color after five month storage at 7.2°C), while Russet Burbank, Goldrush, Russet Norkotah and Shepody were placed into the Class C group (unacceptable fry color after five month storage at 7.2°C). The glucose content of Freedom Russet tubers was 0.59 mg/g after 7.2°C storage; the corresponding fry color measured as Agtron value was 59 (a value of >55 being an acceptable fry color), while the same values for Umatilla were 1.35 mg/g and 59 Agtron, and for Russet Burbank 1.82 mg/g and 54, respectively (a HunterLab colorimeter, Model DP 9000, was used; the white tile calibration values were X=81.96, Y=84.04 and Z=99.03).

Table 6 Fry color scores of Freedom Russet and standard cultivars in North Central Regional Trial[a] (Red River Valley lab)

Treatments[b]	Year	Average fry color (1–5)[c]			Difference with	
		Freedom Russet	Russet Burbank	Russet Norkotah	Russet Burbank	Russet Norkotah
0/15.5/D	2001	3.1	3.0	3.2	0.1	−0.1
3/8.9/D	2002	3.2	3.5	3.6	−0.3	−0.4
5(6)/8.9/D	2003	3.4	4.2	4.1	−0.8	−0.7

[a] Alberta, Manitoba, Michigan and Wisconsin (2001-2003); Minnesota (2001, 2003); North Dakota and Nebraska (2001)

[b] Treatments: months of storage/ temperature of storage/ fried direct

[c] Fry color: 1=very light=000 in USDA chart; 2=00; 3=0; 4=1; 5=2; the upper limit of acceptance in USDA chart is 2

When the tubers were reconditioned at 12.8°C for two months, Freedom Russet had 0.47 mg/g glucose and an Agtron value of 58. The comparable figures for Umatilla and Russet Burbank were 0.47 mg/g and 53, and 1.42 mg/g and 47, respectively (Glynn and Sowokinos 2005).

Porter et al. (2001, 2002, 2003, 2004, 2005) also reported a consistently better fry color for Freedom Russet compared with Russet Burbank when the tubers were processed at harvest and after five months of storage at 10°C or 7.2°C. The tendency for gray color and mealiness of Freedom Russet French fries was very similar to that of Russet Burbank (Porter et al. 2001, 2002, 2003, 2004, 2005).

In post-harvest evaluations, Freedom Russet tubers had similar susceptibility to shatter bruise and blackspot bruise potential as Russet Burbank, and more resistance to skinning and internal damage, as reported by Porter et al. (2005).

Reaction to Diseases

Freedom Russet is resistant to common scab (*Streptomyces scabies*). No scab or only traces were found in the NCRT in 2001 to 2003 (Thill et al. 2002, 2003, 2004). The average common scab resistance scores for Freedom Russet, Russet Burbank, and Russet Norkotah were 9.0, 7.1, and 6.3, respectively (9=no scab lesion), in the Wisconsin Field Trials conducted at Hancock, Wisconsin in 1998–1999. Student t test showed the resistance of Freedom Russet was significantly higher (P=0.05) than the two standard cultivars. Stevenson et al. (2002, 2003) reported no difference for common scab resistance between Freedom Russet and Russet Burbank in Wisconsin scab test plots (Antigo, Wisconsin). Freedom Russet showed a high level of resistance to common scab in the Rhinelander test plots in 2002 and 2005 (Jiang et al. 2003, Navarro et al. 2006). The frequency of Freedom Russet tubers with scab lesions in 2003, a year with heavy scab pressure, was 1.7% and the mean lesion area index (percentage of tuber area covered by lesions) was 8.98 (in the scale 1–9, 1 is 80–100% covered by lesions). The corresponding values of the standard varieties in the trial were: 25.0% and 6.3 for Russet Burbank, 43.3% and 7.1 for Russet Norkotah, 51.7% and 6.8 for Stampede Russet, and 98.3% and 3.0 for Pacific Russet (Jiang et al. 2004). Statistical analysis again showed that Freedom Russet was significantly (P=0.05) more resistant to scab than Russet Burbank.

The scab resistance evaluation conducted in Aroostook State Farm (Maine, 2004), which was included in the National Scab Trial reported by Kathleen Haynes (USDA, Beltsville), showed an average area index of 0.32 and lesion index of 0.28 for Freedom Russet, 0.31 and 0.41 for Russet Burbank, and 0.41 and 0.72 for Ranger Russet. Additionally, Freedom Russet exhibited a high level of resistance in common scab evaluations conducted at Rhinelander, WI; at Heartland Farms in Hancock, WI; and at Alliston, ON, during 2006 and 2007 (Navarro et al. 2007, 2008).

Freedom Russet showed a low incidence of powdery scab (12.7% tubers infected) in the test plots in Potter County, Pennsylvania, in 2004. This incidence was statistically (P=0.05) not different from Russet Burbank (4.9%), but significantly (P=0.05) less than Ranger Russet (23.3%) (Christ et al. 2005). In the second trial conducted in 2005 in the same location, Freedom Russet and Russet Burbank exhibited similar powdery scab performance (Christ et al. 2006).

Freedom Russet was susceptible to early blight (*Alternaria solani*) on foliage, similar to Russet Burbank in trials conducted in Hancock and Rhinelander, Wisconsin, in 1998 and 1999. The area under the disease progress curves (AUDPC) was similar between Freedom Russet and Russet Burbank in 2002, a year with a low incidence of early blight. However, Freedom Russet was more resistant to early blight than Russet Burbank in 2001, a year with a high incidence of the disease (Stevenson et al. 2002, 2003). The incidence of early blight on tubers after artificial wound inoculation was similar between Freedom Russet and Russet Burbank (Stevenson et al. 2002, 2003).

According to results of late blight trials carried out in 2007 in Corvallis, Oregon, in collaboration with Isabel Vales and Solomon Yilma, Freedom Russet vines were as susceptible to late blight (*Phytophthora infestans*) as Russet Burbank (Navarro et al. 2007) or more susceptible than Russet Burbank, in trials conducted in Pennsylvania the same year (Christ et al. 2008). In addition, Stevenson et al. (2002) found that tubers of Freedom Russet were as susceptible to late blight infection (US-8 genotype) as Russet Burbank on artificially wounded and inoculated tubers (51.4–62.2 cm^3 affected volume).

Freedom Russet tubers showed similar responses to infection by the pink rot pathogen (*Phytophthora erytroseptica*) and bacterial soft rot (*Erwinia carotovora*) as Russet Burbank (Stevenson et al. 2002, 2003). Freedom Russet tubers also behaved similarly to Russet Norkotah and Russet Burbank in response to bacterial soft rot inoculation (10.8 mm infected area vs. 10.2 mm and 10.4 mm, respectively) (Robert Rand, University of Wisconsin, unpublished data). The expression of the symptoms of bacterial ring rot (*Clavibacter michiganensis* ssp. *sepedonicum*) in Freedom Russet plants consisted mainly of marginal leaf necrosis 93 days after planting, and marginal leaf necrosis, leaf roll and internal chlorosis after 99 days in vines. Additionally, vascular discoloration (28%), rot and external periderm cracking in tubers were

present (Lisa Piche, Julie Pasche and Neil Gudmestad, North Dakota State University, unpublished data).

Freedom Russet showed tolerance to early dying caused by Verticillium wilt and root lesion nematode (*Pratylenchus penetrans*). The percentage of foliage exhibiting symptoms of early dying in the first week of August 1999 in Hancock (Wisconsin) was 3% (range 0 to 5%) for Freedom Russet, compared to 40% for the resistant standard Reddale (Douglas Rouse, University of Wisconsin, unpublished data). In the last week of August in 1999, the percentage of early dying increased to 55% for Freedom Russet and 95% for Reddale (Shelley Jansky, USDA and University of Wisconsin, unpublished data). Freedom Russet was more resistant to Verticillium than the susceptible standard Russet Norkotah in the NCRT conducted in Becker, Minnesota (Thill et al. 2002, 2003). Freedom Russet had similar RAUDPC values for early dying in fumigated and non-fumigated plots in Wisconsin in 2005 and 2006, whereas RAUDPC for Russet Burbank was decreased by fumigation in 2005 but not in 2006 (LeMere, 2007). Yields for Freedom Russet were lower when fumigated compared to non-fumigated checks in the same trial over both years, but Russet Burbank yields were unaffected or increased by fumigation in 2005 and 2006, respectively.

Biochemical Characteristics

The glycoalkaloid content of Freedom Russet was acceptable at a total of 4.04 mg/100 g fresh tissue, 43.3% solanine and 56.7% chaconine, which is significantly better than Russet Burbank, having a total content of 11.64 mg/100 g fresh tissue, 38.9% solanine and 61.0% chaconine (Kenneth Deahl and Frances Perez, USDA, unpublished data).

The isozyme pattern of Freedom Russet was: *Mdh-1* $1^1 1^1 1^2 1^2$, *Mdh-2* $2^1 2^2 2^2 2^2$, *Got-1* $1^3 1^3 1^4 1^4$, *Got-2* $2^3 2^3 2^3 2^5$, *Pgm-1* $1^1 1^1 1^3 1^3$, *Pgm-2* $2^2 2^2 2^2 2^2$, *Pgi-1* $1^2 1^2 1^2 1^2$, *6-Pgdh-3* $3^1 3^1 3^2 3^2$. The normal script digit represents the locus and the superscript digit represents the allele for the enzymes Malate dehydrogenase (*Mdh*), Glutamate oxaloacetate transaminase (*Got*), Phosphoglucomutase (*Pgm*), Phosphoglucose isomerase (*Pgi*), and 6-Phosphogluconic acid dehydrogenase (*6-Pgdh*), according to the procedure and nomenclature of Douches and Ludlam (1991).

Seed Availability

Freedom Russet was initiated as tissue culture plantlets in 2003 by the Wisconsin Seed Potato Certification Program in the Department of Plant Pathology, University of Wisconsin-Madison. Freedom Russet seed for commercial purposes is available from several WI seed growers listed in the Wisconsin Certified Seed Potato Directory. Freedom Russet is the property of the Wisconsin Alumni Research Foundation (WARF). Plant breeder's rights have been granted to WARF in Canada and Plant Variety Protection is pending in the United States. Licenses to grow Freedom Russet for seed purposes can be obtained from WARF.

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