

History and Origin of Russet Burbank (Netted Gem) a Sport of Burbank

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Abstract The importance of Russet Burbank, the world's foremost French fry processing cultivar, requires a complete description of its origin. Its maternal lineage included Rough Purple Chili, Garnet Chili, Early Rose, and Burbank. An incorrect but widely disseminated account attributes the origin of Russet Burbank to Colorado potato grower Lou D. Sweet, with 1914 often given as the date of introduction. However, it is likely that Russet Burbank was originally released in 1902 as May's Netted Gem by L. L. May & Co. (St. Paul MN). The names Netted Gem and Russet Burbank were used synonymously for many decades. Isoenzyme, multiplex PCR, and SNP data confirm Russet Burbank as a mutation of Burbank and do not support a seedling origin. Russet Burbank was

found to be similar to Burbank in processing and nutritional characteristics. A goal of this effort is that descriptions of Russet Burbank's lineage and origins will be corrected by seed companies in lists of potato varieties and at world repositories holding Russet Burbank and its progenitors.

Resumen La importancia de Russet Burbank, la principal variedad mundial para la industria de las papas a la francesa, requiere de la descripción completa de su origen. Su linaje materno incluyó Rough Purple Chili, Garnet Chili, Early Rose, y Burbank. Una versión incorrecta pero ampliamente diseminada atribuye el origen de Russet Burbank al productor de papa de Colorado Lou D. Sweet, con 1914 como a menudo dado como el año de introducción. No obstante, es probable que Russet Burbank fue liberada originalmente en 1902 como May's Netted Gem por L. L. May & Co. (St. Paul MN). Se usaron los nombres de Netted Gem y Russet Burbank como sinónimos por muchas décadas. Datos de isoenzimas, múltiple PCR y SNP confirman a Russet Burbank como una mutación de Burbank, y no respaldan el origen por plántula. Se encontró que Russet Burbank es similar a Burbank en características de procesamiento y nutricionales. Una meta de este esfuerzo es que las descripciones del linaje de Russet Burbank y sus orígenes sean corregidos por las compañías de semilla en listas de variedades de papa y en las reservas mundiales que conserven Russet Burbank y sus progenitores.

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Introduction

Just as the plant breeder Luther Burbank was a legendary figure in his day but is now seldom mentioned (Stansfield 2006), his potato cultivar Burbank was an important table stock cultivar for decades but is currently little-known and its origins have been obscured by legend. However, the Burbank sport, Russet Burbank, became the dominant potato cultivar in North America during the twentieth century. Originally a popular fresh market baking potato, it became a giant in the French fry processing world. The organoleptic properties of Russet Burbank, promoted to millions of customers over decades by grocers, railroads, trade organizations, and quick service restaurant (QSR) franchises, set the standard for potato texture and taste in North America. The story of the parentage of Russet Burbank is a fascinating one, as several of its progenitors were historically and/or economically important cultivars that were produced by 19th Century plant breeders in USA. The early history of Russet Burbank, from its chance finding, to its wide scale adoption by the potato industry, is equally interesting. As the Potato Association of America (PAA), established in 1913, enters its second century, we take the opportunity to look back at the most important potato cultivar of the PAA's first century. Here, we clarify the parentage of Russet Burbank, describe for the first time its origin, review data showing that it is a sport of Burbank, and note its important contributions to the frozen fry processing industry and to our diet. In doing so, we pay homage to those members of the PAA whose work with Russet Burbank made a lasting contribution to the potato industry worldwide.

Progenitors of Russet Burbank

One effect of the late blight (*Phytophthora infestans*) epidemic in the mid-1840s, which precipitated famine and emigration from Europe, was to eliminate most of the existing potato cultivars because of their susceptibility to the disease (Davidson 1935; Glendinning 1983). Many of the remaining cultivars were highly inbred and had been selected against berry production since this was thought to detract from yield (Glendinning 1983). In the 1850s cultivated potato accessions were imported from South and Central America into USA and Europe in an effort to find disease resistance and overcome low fertility in the few remaining cultivars. One landrace obtained from Panama and introduced into the USA by the amateur botanist and potato breeder Reverend C.E. Goodrich of New York (1851) was Rough Purple Chili (Douches et al. 1991; Glendinning 1983; Goodrich 1863). The geographic origin of Rough Purple Chili is uncertain, but Goodrich thought it came from the Chilean coast (Glendinning 1983) and named it after its presumed place of origin, Chili, as it was spelled in the mid-1800s. It is one of only two founding introductions (the other is Daber) that have been definitively

identified and whose performance was good enough for them to be kept for parents. More than 400 USA and European cultivars have Rough Purple Chili in their heritage (Douches et al. 1991). Unfortunately, Rough Purple Chili is no longer available.

In the pedigree of Russet Burbank only the maternal parents are known (Fig. 1). Early potato breeders usually relied on open pollination so the male parent was often unknown, unrecorded, or kept as a trade secret (Glendinning 1983). One very early open-pollinated derivative of Rough Purple Chili was a seedling selected by C.E. Goodrich in 1853 and released by him in 1857, named Garnet Chili (Clark and Lombard 1946; Darling 1959; Plaisted and Hoopes 1989) (Fig. 2a). An open-pollinated derivative of Garnet Chili was Early Rose, selected by A. Bresee of Vermont in 1861 and introduced in 1867 by D. S. Heffron and in 1868 by D. K. Bliss & Sons (Clark and Lombard 1946; Darling 1959) (Fig. 2b). Rough Purple Chili, Garnet Chili, and Early Rose were found in the ancestry of all of the 44 most prominent U.S. cultivars with published pedigrees examined by Love (1999).

Russet Burbank (Fig. 2d) is the most prominent of those 44 cultivars, which is why Luther Burbank is such an important figure in the history of North American potatoes. As a young man (Fig. 3a), Luther's attention was drawn to a rare fruit in a planting of Early Rose in his mother's garden in New England (Burbank 1914) or Concord MA (Burbank 1914). He monitored the progress of this berry during its maturation and then spent several days meticulously searching for it on the ground after it had fallen from the vine. It contained 23 seeds (Burbank 1914), or perhaps a few more (Grubb and Guilford 1912), that he planted in 1873. One exceptional line with white skinned, large smooth tubers (Fig. 2c) was retained and eventually sold to a seed company called Messrs. J.J.H. Gregory & Son which released it as 'The Burbank Seedling' in 1876 (Clark and Lombard 1946; Burbank 1914). This cultivar name was shortened to Burbank through popular usage, although other similar synonyms were used (Table 1). Luther Burbank moved to California and increased Burbank seed tubers there. Burbank became very popular and was promoted by the US Department of Agriculture (USDA). Registration of Burbank in the USA is considered to be 1876, the year it first appeared in Messrs. J.J.H. Gregory & Son's seed catalog (Stuart 1923), and about the time of its first introduction to Idaho (Davis 1992). The Burbank potato achieved great importance over the next several decades during which time Luther Burbank established himself as a prolific, if unorthodox, plant breeder (Fig. 3b). Scientists of his era did not understand or respect his methods, despite his many successes (Crow 2001; Stansfield 2006). The distinctive Burbank became "the standard of excellence" for table stock potatoes up the Pacific coast from Mexico to Alaska as well as in many other states (De Vries 1907). At the turn of the century, it was contributing \$17,000,000 annually to the

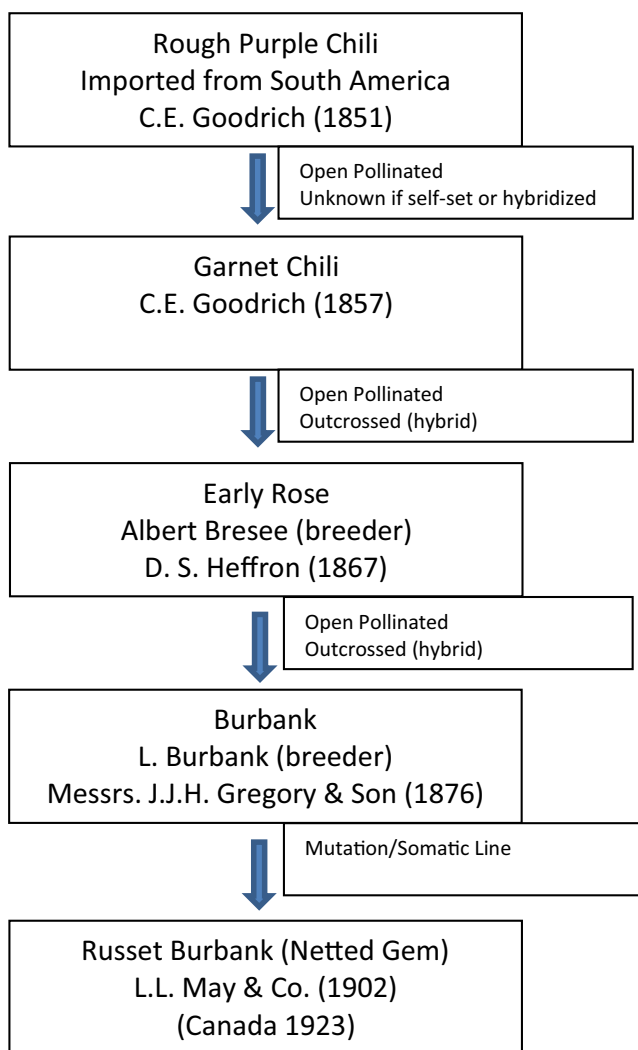


Fig. 1 The lineage of Russet Burbank (Netted Gem) showing its immediate maternal parents Rough Purple Chili, Garnet Chili, Early Rose, and Burbank, the breeder and/or company that released it, and the release date

agricultural economy of USA by USDA estimates (De Vries 1907).

Origin and Early History of Russet Burbank

Luther Burbank wrote little about Russet Burbank potatoes, but he did include a photograph of “Russet Burbanks” in his notes, later assembled by the Luther Burbank Society into a book describing his life’s work and his philosophy as a plant breeder (Burbank 1914). One figure caption states “These Burbank potatoes raised by Mr. Lou D. Sweet, of Denver Colorado, have somewhat modified their coat in a way that does not add to their attractiveness. It is said, however, that this particular variant is peculiarly resistant to blight, which gives it exceptional value”. This statement has been misinterpreted to mean that Louis D. Sweet selected Russet Burbank (PAA 2013a; Idaho Potato Commission 2013). In

some cases, 1914 is mistakenly listed as the date of introduction for cultivar Russet Burbank (PAA 2013a). However, contemporary accounts that link Lou Sweet to the introduction of Russet Burbank are lacking and while he may have brought it to the attention of Luther Burbank, it is unlikely that he played a role in its discovery.

Lou Sweet and Frank Sweet (no relation) were business partners and successful potato growers in the Carbondale district of Colorado. There is no doubt that they raised Russet Burbank potatoes on their ranches (Fitch 1921, Stuart 1923), but Lou Sweet never claimed to have selected the potatoes he was growing. In an account describing their work growing seed potatoes, Lou Sweet makes no mention of the origin of Russet Burbank (Olin 1921). Edward Claussen, a seed grower who came to Carbondale after the Sweets and who was growing Russet Burbank seed there by 1912 (Fig. 4a), recalled traveling all over the inter-mountain region to find the finest Russet Burbank seed, but made no mention of a local origin for Russet Burbank (Olin 1919). Eugene Grubb was Lou Sweet’s neighbour in Carbondale. He traveled widely in the US and Europe, looking for the best potato cultivars to grow on his Mt. Sopris Farm (Grubb and Guilford 1912), and was Vice President of the PAA from its founding in 1913 until 1915 (PAA 2013b). In his landmark book *The Potato*, Grubb does not mention Russet Burbank, although he has a chapter on the Burbank potato that refers to conversations with Luther Burbank in Santa Rosa CA. In a textbook that featured photographs of Lou and Frank Sweet and a photograph provided courtesy of Lou Sweet showing “a field of Russet Burbank (Netted Gem) potatoes” growing on the Sweet ranch. William Stuart asserted, “Nothing definite is known about the origin of the Russet Burbank” (Stuart 1923). This claim cannot be dismissed easily given that Stuart was an expert on USA potato cultivars who had a long association with Lou Sweet. During the 3 years (1916–1918) when Lou Sweet was President of the PAA (PAA 2013b), William Stuart was Secretary and Treasurer of that organization. Stuart took over as PAA president in 1919. It seems highly improbable that Stuart would not have heard of Lou Sweet’s discovery if this had happened.

The name “Russet Burbank” appears in print by 1910, but from the beginning Russet Burbank went by other names before the name was standardized. This likely reflects the fact that Russet Burbank was not originally a trade name but rather a description of a Burbank with russet skin. Luther Burbank’s use of “Russet Burbanks” is consistent with this interpretation. Researchers at the Colorado Experiment Station wrote “Russet we believe to be most appropriate for the promising new sort which has carried the indefinite names White Beauty and Russet Burbank.” (Fitch and Bennett 1910). “Russet” was not mentioned in the Colorado Potato Industry report penned 3 years earlier (Bennett, 1907). Neither was it mentioned in a contemporary list of recommended potato cultivars for

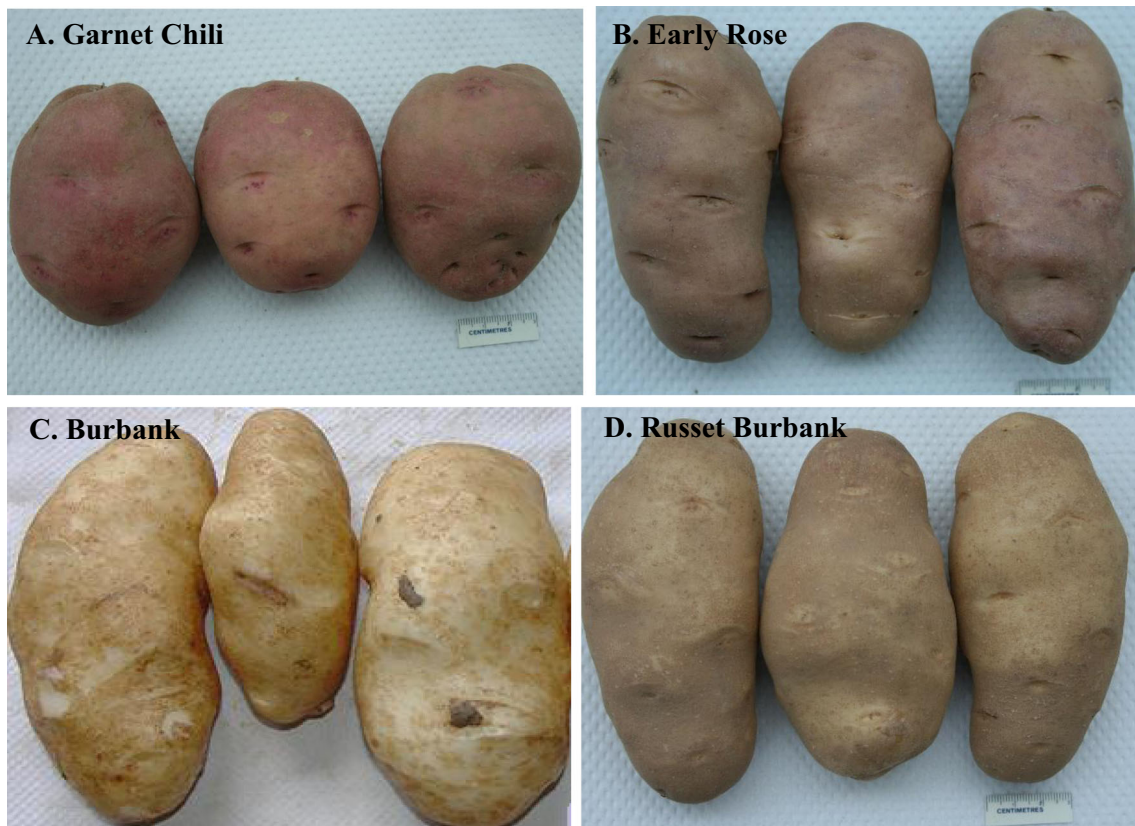


Fig. 2 Showing A. Garnet Chili, B. Early Rose, C. Burbank, and D. Russet Burbank. A, B, and D were grown in the Potato Gene Resources evaluation plot at AAFC-Fredericton, NB (127 days, 2012). C was grown in Florenceville, NB (109 days, 2006)

Colorado (Grubb and Guilford 1912). It therefore seems likely that it truly was “a promising new sort” in 1910. One early report from Idaho stated, “The Netted Gem is a strain of the Russet Burbank” (Olin 1912). One brief report commented on “Burbank and Netted Burbank varieties” harvested in Washington in 1908 (The Kennewick Courier, 1908). A report on cultivar trials conducted in 1912 and 1913 at the Idaho Experiment Station mentioned the “Netted Gem, otherwise known as the English Russet and Russet Burbank” (Kennard et al. 1914). The names Russet Burbank and Netted Gem appeared together as synonyms for many decades. Netted

Gem, and the diminutives “Gem” or “Gemmy” are still used in some farmers’ markets in New Brunswick, Canada (Fig. 4c). Other synonyms for Russet Burbank are listed in Table 1.

The Netted Gem seed tubers used by the Idaho Experiment Station for their 1912 and 1913 field trials in Northern Idaho were sourced from “Yakima country” (Kennard et al. 1914). Prize-winning Netted Gem tubers produced in Washington at this time are shown in Fig. 4b. Netted Gem, “a very large and excellent russet variety” was in commercial production in the Yakima Valley by 1907 (The Daily East Oregonian 1907). A

Fig. 3 Luther Burbank was born March 07, 1849 and died April 11, 1926. He is pictured here A. as a young man (Google images; http://www.encyclopedia.com/topic/Luther_Burbank.aspx) and B. later on in life (Google images; <http://www.biography.com/people/luther-burbank-9231360>)

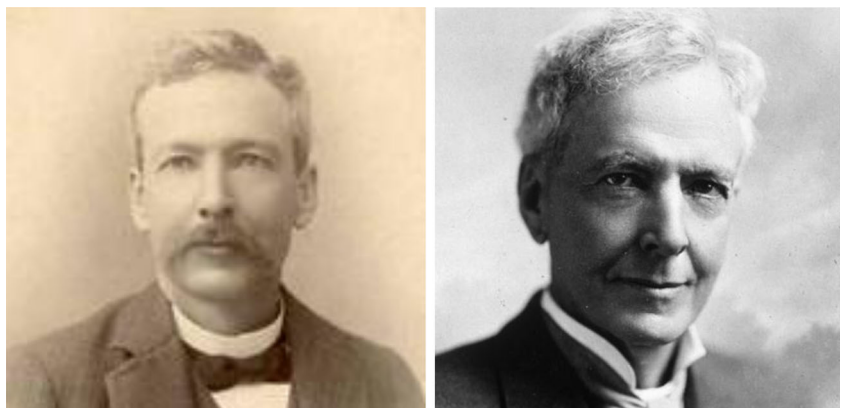


Table 1 Synonyms used for cultivars Burbank (Burbank 1914; Darling 1959) and Russet Burbank (Clark and Lombard 1946; Darling 1968; Davis 1992; Hardenburg 1949; Kennard et al. 1914; Stevenson 1949; Stevenson et al. 1955)

Cultivar	Synonyms
Burbank	Burbank's Seedling Seedling of Burbank California Burbank Salinas Burbank
Russet Burbank	Burbank's Russet California Russet English Russet Golden Russet Idaho Potato Idaho Baker Idaho Russet Klamath Russet Netted Gem (Gem, Gemmy)

year later, Hazen Titus, newly appointed Superintendent of Dining Cars on the Northern Pacific Railroad, was reported to have been on his way to Seattle when he overheard two Yakima potato growers talking about how difficult it was to sell jumbo-sized Netted Gems, weighing up to 5 lb each (McKenzie 1990). Intrigued and sensing a marketing opportunity, Titus acquired some of the tubers to see if they were suitable for use on the Northern Pacific's dining cars. Tubers of approximately 2 lb each were sourced from the Yakima valley and the first "Netted Gem Baker" was sold on the Northern Pacific on Feb 8, 1909 (Northern Pacific Menu 1917). Jumbo-sized russets were served on "The Route of the Great Big Baked Potato" for many decades. Contemporary reports of large yields and giant tubers being grown in the Yakima Valley along the Sunnyside Canal are consistent with this account (The Ranch 1908). Fourteen years later it was noted that Netted Gem was "in favour as the "big baked

potato"" (Ruzicka 1922) and that Russet Burbank was "made famous by the railroads of the northwest, as "the Great Big Baked Potato" (Fitch 1922). Titus was credited with causing an "enormous boom for Idaho and Washington potatoes" (Anon. 1918).

Cultivar characteristics and relative merit of Netted Gem potatoes were described in several early reports from agricultural experiment stations. "May's Netted Gem" was included in cultivar trials conducted in North Dakota in 1902 and 1904 (Shepperd 1905; Shepperd and Ten Eyck 1903). Tubers from those trials were described as high-yielding and scab resistant. In Ohio trials carried out in 1905, Netted Gem was described as having a heavy netted coating over the entire surface and being a good keeper that does not sprout early (Green and Waid 1906). Netted Gem was included in research trials in Washington State in 1905–1908. Tubers were described as large and elongated in shape, with russet netting (Craig 1910). In 1907, Netted Gem was one of 8 varieties planted in cultivar trials conducted at Twin Falls ID for the North Side Land and Water Company and the Twin Falls Salmon River Land and Water Company. In this trial, "Perhaps the most promising variety was the Netted Gem, giving a large yield of fine quality even-sized potatoes" (Stephenson 1909). Netted Gem appears in trials conducted by Idaho Experiment stations in 1910–1913. In one report on those trials, Netted Gem is described as "a well-known variety, sometimes called Russet Burbank", and an excellent keeper (Kennard et al. 1914). The first edition of "Growing the Idaho Potato" featured a photograph of Netted Gem tubers and stated, "In eastern markets, the reputation of Idaho potatoes is based on two varieties – i.e., the so-called Idaho Whites (Idaho Rurals) and Idaho Russets (Netted Gems)." (Bennett 1919). Russet Burbank is not mentioned in this report (Bennett 1919). Netted Gem made a good showing on irrigated lands in Oregon trials conducted in 1912–1913 (Scudder



Fig. 4 A century of Russet Burbank (Netted Gem) tubers. A. Russet Burbank tubers grown in the district of Carbondale, CO and harvested in 1918 after 6 years of hill selection. Originally published in *The Potato Magazine* (Olin, 1919), an early publication of the PAA. B. Prize winning

Netted Gem tubers from the Waterville (WA) Potato Carnival, 1911 (Ogle 1915). C. Gem or Gemmy, a diminutive of Netted Gem is still in use at farmers' markets in New Brunswick, Canada (photographed at the North Side Farmer's Market, Fredericton, NB fall 2012, DJD)

1914). None of these early trials, or any conducted later that we are aware of, contained both Netted Gem and Russet Burbank as independent entries.

Researchers in North Dakota, Ohio, and Washington (Craig 1910; Green and Waid 1906; Shepperd 1905; Shepperd and Ten Eyck 1903) attributed the Netted Gem cultivar to L. L. May & Company of St. Paul MN. The most complete, albeit highly biased, early description of “May’s Netted Gem Potato” comes from May’s 1902 Catalogue of Northern Grown Seeds (Fig. 5). Many of the characteristics that are associated both historically and currently with Russet Burbank, including high yields, excellent culinary properties, excellent storage, long dormancy, and attractive skin are mentioned. The claim of drought resistance must be viewed with some scepticism, as it appears to be based on 1 year’s data. However, it must be viewed in context, as a comparison with other cultivars grown at that time. For example, when a shortage of irrigation water caused a partial failure of the potato crop at the Jerome sub-Station, Netted Gem was listed as one of six cultivars worthy of note out of fifty grown (Dewey 1915). Likewise, the claim that “large” tubers were dug 70 days after planting is likely a marketing exaggeration. The 1901 crop year in Minnesota was unusually warm in May, June and July and this could have promoted unusually rapid tuber bulking. However, it seems unlikely that tubers harvested on July 20 could have been large by that time. Two photographs of Netted Gem tubers are included in L.L. May’s catalogue listing. One shows a single long tuber and the other a group of oblong tubers arranged in rows. One cannot safely assume that these photographs depict typical tubers, but the variation in shape and extent of netting seen in these photographs is consistent with the variation observed for Russet Burbank grown in the Midwest. Remarkably, May’s catalogue listing contains a paragraph that describes the chance finding of the line 7 years prior by an unnamed ranchman in Montana, who found it growing in a field that the year before had been planted with the three cultivars: Burbank, Maggie Murphy, and Ohio (Fig. 5). We know nothing else about how this clone was found, described in May’s catalog as “a seedling”.

Potato growers at the time would have been drawn to a highly russeted tuber, as russetting was seen as an indication of tuber quality (Fitch 1922; Fitch and Bennett 1910; Green and Waid 1906). The assertion in May’s advertisement that Netted Gem is blight resistant can be questioned, but Luther Burbank echoed this statement (Burbank 1914). The authors have not found pathology reports where relative resistance or tolerance of Burbank and Russet Burbank (Netted Gem) were compared. The changed skin characteristics of Russet Burbank compared with Burbank may have led to assumptions of increased resistance to “blight” which may have included potato scab (*Streptomyces scabies*) and late blight, in comparison to other cultivars of that era. These differences may have been slight. For example, the Potato Handbook (1959)

described Burbank as “susceptible to common potato diseases” and Russet Burbank as being “somewhat resistant to common scab but susceptible to other common potato diseases.” Current descriptors indicate that ‘Russet Burbank’ has moderate resistance to common scab, and is susceptible to Fusarium dry rot, Fusarium and Verticillium wilt, PLRV, PVY, PVX and tuber net necrosis (PAA 2013a; CFIA 2013).

Usage of the Names Netted Gem and Russet Burbank

Potato shows were a popular way for growers, grower associations and geographic regions to demonstrate the quality of their products. Contest announcements and reports of prizes won give an indication of the cultivar names in use by industry during the first 3 decades of the twentieth century. For example, the announcement for a competition to be held in conjunction with the 1915 PAA meeting in Grand Rapids Michigan lists “Burbank, russet selection” as one of eleven Class I cultivars eligible for prizes, but it does not mention Netted Gem (Stuart 1915). The announcement for the Western Potato Show to be held in Denver on January 19–24, 1920 listed “Russet Burbanks, or Netted Gems” among the principle cultivars that would be accepted (Anon. 1919a). Netted Gem tubers from the Deschutes Valley in central Oregon won “best in show” at the International Potato Show in Duluth, MN, in 1921 (Ballard 1922), but the announcement for the show, like that for the Northern Minnesota Potato Show in Duluth 3 years earlier, listed Burbank Russet as an eligible cultivar (Anon. 1919b; Anon. 1921). A clear illustration of how Netted Gem, Russet Burbank and other names were used interchangeably comes from the revised version of “Growing the Idaho Potato” (Bennett 1927). “The enviable reputation which Idaho potatoes hold in outside markets is very largely based on the cultivar known as the Netted Gem or Russet Burbank, commonly known in the eastern markets as the Idaho Russet”. This reputation persists to this day.

In an attempt to encourage uniformity in potato cultivar names, the Committee on Nomenclature of the PAA outlined a scheme for naming cultivars that are selections or sports of existing cultivars (Clark et al. 1941). They stated “The Russet Burbank is commonly referred to in trade papers, and frequently in Experiment Station Bulletins, as Netted Gem, Idaho Russet, or as Russets”. To eliminate confusion that this might cause, they suggested that the name Russet Burbank should be used. It was also suggested that the true name be followed by its trade name or synonyms in parentheses, e.g. Russet Burbank (Netted Gem), in those cases when it is desirable to indicate a trade name.

Germplasm Holdings of Russet Burbank and Progenitors

Major world repositories were queried about their holdings of Russet Burbank and its progenitors (Table 2). Potato Gene

MAY'S NORTHERN GROWN SEED POTATOES—BEST FOR ALL CLIMES. 3



MAY'S NETTED GEM POTATO, THE MARVELOUS MONTANA SEEDLING.
THE HEAVIEST YIELDING SORT GROWN.

Its appearance IS MOST STRIKING AND BEAUTIFUL. It is the handsomest variety we have ever seen and hundreds of good potato judges bear us out in this statement. In shape it is oblong—nearly straight, well set with eyes all over. The skin is of most curious formation for a potato, being very closely netted and veined like the Rocky Ford melon. It is rather thick and does not bruise easily thus enabling it to withstand shipping exceedingly well as it will reach destination in prime condition and appearance. It is of light russet color, very pleasing and beautiful.

The Plants are at all times clean, healthy and vigorous, never known to blight, while their tough fibrous nature seems to withstand the attacks of bugs better than any variety we have ever grown.

Its History—Unlike many good varieties that have been introduced after patient years of hybridizing and careful nursing, this wonderful variety is the result of mere accident. The chance product of a chance seedling found growing in a field that had been planted to Ohio, Burbank and Maggie Murphy the year before by a ranchman in Montana 7 years ago, the product carefully saved and replanted until last year when we purchased the stock and offer for the first time this wonderful product of the prairie, the most marvelous variety ever introduced.

The Illustrations shown herewith are from photographs of average size potatoes. They are not too large to be good nor too small to be unfit for seed or cooking. They are very uniform in size, averaging 5 to 8 inches in length each potato containing from 20 to 30 eyes well distributed, making it the most prolific seed variety ever offered. **Prices for 1902: Lb. 30c, 3 lbs. 75c, peck \$1.25, bu. \$4.00, bbl. (2 3-4 bu.) \$10.00.**

I tested both quality and yield of The Netted Gem Potatoes from samples you gave me. I planted 33 potatoes and harvested from them 17 bushels of nice tubers; by far the best yield of any potato I ever grew. As to quality they are superior to anything we ever used, being of nice flavor, white and dry.

A. STAFFORD.

Brainerd, Minn., Nov. 1, 1901.

GENTLEMEN: If I could reconstruct the English language to place an especial emphasis on the good qualities of May's Netted Gem Potato I would certainly do so. Having grown them for two seasons on varied grades of soil as a test, I find they are what we have been looking for—a success under any and all circumstances. I have tested and raised nearly all varieties of potatoes as they came on the market for many years and I have never found anything that has the combined good qualities of May's Netted Gem. As a yielder it has no equal; even in the dry season of 1901, where many of my other varieties were a practical failure and my Burbanks yielded nearly two hundred bushels per acre, May's Netted Gem yielded three hundred and fifty bushels per acre, all fine stock. They had no better care nor better soil than my other varieties. Their keeping qualities cannot be equalled; they will be found in excellent condition in June; their quality always superior to other varieties. The past season we planted the first week in May, and July 20th used from them and found them excellent. I challenge any one to produce a better yielder or keeper, or whiter meat—better flavored potato than the Netted Gem.

Wm. DODD.



Fig. 5 Advertisement for May's Netted Gem Potato as printed in May's Catalogue of Northern Grown Seed, L.L. May & Company, St. Paul, MN (1902)

Resources Canada in Fredericton, NB, holds Garnet Chili, Early Rose, and Russet Burbank, with plans to obtain Burbank. The USDA repository in Sturgeon Bay, WI, holds Garnet Chili, Early Rose, Burbank, and Russet Burbank.

The Burbank accession is undergoing PVS-elimination through thermotherapy and meristem tip culture. In Europe, the only holdings for Garnet Chili and Burbank are at INRA in Rennes, France although the Burbank accession is PVX-

Table 2 Major world repositories holding Russet Burbank and its progenitors

National Potato Cultivar Collections	Garnet Chili	Early Rose	Burbank	Russet Burbank
Potato Gene Resources Canada, Agriculture and Agri-Food Canada, Fredericton, NB http://pgrc3.agr.gc.ca/index_e.html	X	X	Requested	X
The United States Potato Genebank (NRSP-6) Sturgeon Bay, Wisconsin, USA http://www.ars-grin.gov/ars/MidWest/NR6/	X	X	PVS	infected
The Potato Collection of France, INRA/Université Rennes 1, Rennes, France http://www7.rennes.inra.fr/apbv	X	X	PVX	infected
The SASA (Science and Advice for Scottish Agriculture) Potato Collection, Edinburgh, UK www.sasa.gov.uk	-	X	-	X
The Potato Collection of Spain, The Basque Institute for Agricultural Research and Development (Neiker-Tecnalia), Alava, Spain www.neiker.net/neiker/gemoplasma/	-	X	-	-
The Nordic Genetic Resource Center (NordGen) Potato Collection, Alnarp, Sweden www.ngb.se/sesto/index.php?scp=ngb	-	X	-	-
Institute of Plant Genetics and Crop Plant Research, IPK, Gross Lüsewitz, Germany http://glks.ipk-gatersleben.de/	-	X	-	X
N.I. Vavilov Institute (VIR), 44 B Morskaya Str., 190000 St. Petersburg, Russia www.vir.nw.ru	-	X	-	X
The Potato Collection of Ireland, The Tops Potato Centre, Raphoe, Co. Donegal, Ireland www.agriculture.gov.ie/farmingsectors/crops/seedcertification/topspotatocentre/	-	-	-	X
International Potato Center (CIP) Lima, Peru http://cipotato.org/genebank	-	-	-	-

* information gathered by phone or through email correspondence or websites last accessed July 17, 2013

infected. INRA also holds Early Rose and Russet Burbank. Early Rose is held in several other European repositories (Edinburgh, Scotland; Alava, Spain; Alnarp, Sweden; Gross Lüsewitz, Germany) while Russet Burbank is held in Edinburgh, Scotland, Gross Lüsewitz Germany and Donegal, Ireland. The Vavilov Institute in St. Petersburg, Russia, holds field-grown tubers of Early Rose and Russet Burbank (CFIA 2013). The Potato Centre (CIP) in Lima Peru does not hold Russet Burbank or its progenitors.

Published Cultivar Descriptors for Burbank and Russet Burbank

Garnet Chili and Burbank were never registered in Canada and are absent from the Canadian Food Inspection Agency (CFIA) 2013 potato cultivar list, which does include Early Rose and Russet Burbank (CFIA 2013). The release date for Russet Burbank is often confused with that of Burbank and generalized, as “around 1880” (CFIA 2013; Plant Gene Resources of Canada, GRIN-CA 2013) or listed for both cultivars as 1876 (Thornton and Siczka 1980). Canadian registration for Russet Burbank was in 1923 (CFIA 2013). Russet Burbank is incorrectly described as having been bred and selected by Luther Burbank in Santa Rosa, CA (CFIA 2013; Plant Gene Resources of Canada GRIN-CA 2013; British Potato Variety Database 2013) or having been bred and selected by Lou Sweet from a sport of Burbank (CFIA 2013; GRIN-Plant Gene Resources of Canada 2013). In some cases the entry is confusing; “pedigree: Early Rose (Sport of

Burbank)” (USDA 2013). The European Cultivated Potato Database (<http://www.europotato.org/menu.php>) incorrectly lists both Sweden and the USA as the country of origin of Early Rose and both the Netherlands and the USA as the country of origin of Russet Burbank. The authors noted similar incorrect descriptors for Russet Burbank by major seed tuber distributors in North America. Origin descriptors for Burbank and Russet Burbank are suggested in Table 3.

The year 1908 is sometimes listed as the year of introduction for Russet Burbank (Hutten and Berloo 2001; Folsom 1945). This can be attributed to an incorrect reading of Stuart (1923) by Folsom (1945). In his list of varieties of potatoes, Stuart does not give a date of introduction for Russet Burbank (Netted Gem, California Russet), but he does list references for two other cultivars in the Burbank group (Stuart, 1918). These include the Farmers Seed Catalog from 1908 and the Hammond Seed Catalog from 1901. Both catalogues refer to the cultivars Cambridge Russet and California Russet. Folsom appears to have mistakenly interpreted the 1908 date in Stuart’s entry as the date of introduction for Russet Burbank. Cambridge Russet and California Russet were both long russets, and one can fairly ask if they or another long russet might have been the source of Russet Burbank rather than May’s Netted Gem. Although it is impossible to be certain, it seems unlikely given the consistent and widespread use of the name Netted Gem from the time of its introduction onward. Hammond’s 1901 seed catalogue lists “California Russet or Cambridge Russet” as the same cultivar and describes it as “russet brown with a fine netting”, a description that differs

Table 3 Recommended descriptors for Burbank and Russet Burbank

Cultivar	Descriptor
Burbank	A seedling selected in 1873 from Early Rose (male parent unknown) by Luther Burbank of Concord, Massachusetts. Introduced by Messrs. J. J. H. Gregory & Son of Marblehead, MA ca. 1876
Russet Burbank (Netted Gem)	A sport (mutation or somatic line) of Burbank. Introduced as Netted Gem by L.L. May & Co. of St Paul, MN (1902). Originator unknown.

from the usual description of Russet Burbank as heavily netted. More convincingly, Stuart provided seed tubers to his successor for scab trials at the Vermont Experimental Station in 1914–17. Both Cambridge Russet and Burbank's Russet were included in those trials, and Burbank's Russet was found to have a thicker cork layer than Cambridge Russet (Lutman 1919). California Russet, but not Netted Gem or Russet Burbank, was included in variety trials conducted by the University of Minnesota Agricultural Experiment Station from 1905–1909 (Kohler 1910). Kohler (1910) stated that California Russet “seems to be the same as Golden Russet, Netted Gem, and others”. He goes on to discuss “pernicious practices of some dealers in seed potatoes”. These included marketing valuable new cultivars under a different name, giving established cultivars new names, not taking care to keep seed stock pure, and substituting one cultivar for another (Kohler 1910). Such “pernicious” practices were an important justification for the establishment of formal cultivar registration. The California Russet described and pictured in the First Annual Catalog of the Dakota Improved Seed Company (1908) appears to be very similar to Russet Burbank. This variety, like other long russets of the time that appeared indistinguishable from Russet Burbank (Netted Gem), may have been Russet Burbank (Netted Gem) sold under a synonymous name.

Comparison of Russet Burbank Accessions for Field and Processing Quality Performance

The “demise of Burbank”, and “comeback of Burbank with a russet overcoat” was described by Fitch (1922). Fitch also pointed out wide variations in Russet Burbank tuber type, based on growing locations. For example, tubers were slender where grown in heavier, warmer soils and more typically short, wide, and flat under more ideal northern conditions. Researchers have compared the performance of Russet Burbank accessions from different repositories at least three times (Coleman et al. 2003; Love et al. 1992; Wright and Mellor 1976). Wright and Mellor (1976) compared five virus-free accessions, two British Columbia Netted Gem clones, and three Idaho Russet Burbank clones, for 3 years (1973–1975)

at Pemberton, BC, Canada. No significant differences were observed in total yield and tuber specific gravity. Love et al. (1992) compared 10 Russet Burbank (Netted Gem) accessions for 2 years (1987–1988) at Aberdeen, Idaho, and found that an Idaho clone (known to have PVX infection) and a New Brunswick clone (origin unknown) had inferior performance during the 2 years in Idaho. One of the clones used in both the Wright and Mellor (1976) and Love et al. (1992) studies was reported to have been grown in the Lemhi Valley of Idaho since 1910, and “was possibly the first Netted Gem (Russet Burbank) clone taken to Idaho” (Wright and Mellor 1976). Coleman et al. (2003) tested 11 Russet Burbank accessions from across North America, maintained at the Plant Propagation Centre (Fredericton, NB). The 11 clones included 2 from New Brunswick, 2 from Prince Edward Island, 1 from British Columbia, 1 from Colorado, 2 from Idaho, 1 from Manitoba, and 2 from other places. Genomic DNA fingerprinting confirmed that all 11 accessions were Russet Burbank. The 3-year (1999–2001) test was conducted at Agriculture and Agri-Food Canada's Potato Research Centre (Fredericton, NB). The clones exhibited some difference in earliness of chemical maturation in the field. However, there was no clear evidence for consistent differences in pre- or post-harvest performance that would justify preferential selection or use of a specific Russet Burbank clone in New Brunswick. Whether the slight differences in maturity observed among the accessions can be attributed to genetic or epigenetic change, remains unknown (Coleman et al. 2003). The total and marketable yields in these New Brunswick trials were similar for the 11 clones (Mikitzel et al. 2002). While certain geographical difference might exist among accessions, productivity is apparently more stable than sugar content related to processing quality traits.

Confirmation of Breeding Lineage and Mutant Status of Russet Burbank

Garnet Chili, Early Rose and Burbank were produced by open pollination; seeds could have resulted from selfing or natural hybridization. As Rough Purple Chili no longer exists it is not possible to definitively establish whether Garnet Chili resulted from selfing or hybridization (Douches et al. 1991). Isoenzyme analysis conducted by Douches et al. (1991) showed that Early Rose was derived from hybridization of Garnet Chili. It also showed that Burbank was derived from hybridization of Early Rose. This disproves the claims of the breeder Albert Bresee, who believed that Early Rose came from self-set Garnet Chili (Clark and Lombard 1946; Darling 1959). It also disproves assumptions held by Luther Burbank, who firmly believed that the fruit he found was a result of self-set Early Rose (Burbank 1914). Up to half a million Early Rose were planted by Burbank during his lifetime, largely in an effort to produce a potato superior to Burbank. Partly this was driven by his mistaken assumption that Early Rose had been

selfed to produce Burbank. Among the candidates for pollen parent of Burbank are the siblings of Early Rose released by Albert Bresee; some are even from the same seed ball. In particular, Peerless, which was also called Pearl, as described in Best's Potato Book (Best 1870) had several traits in common with Burbank: "skin dull and white, occasionally russeted; eyes shallow, oblong; flesh white, mealy; grows to a large size and enormously productive".

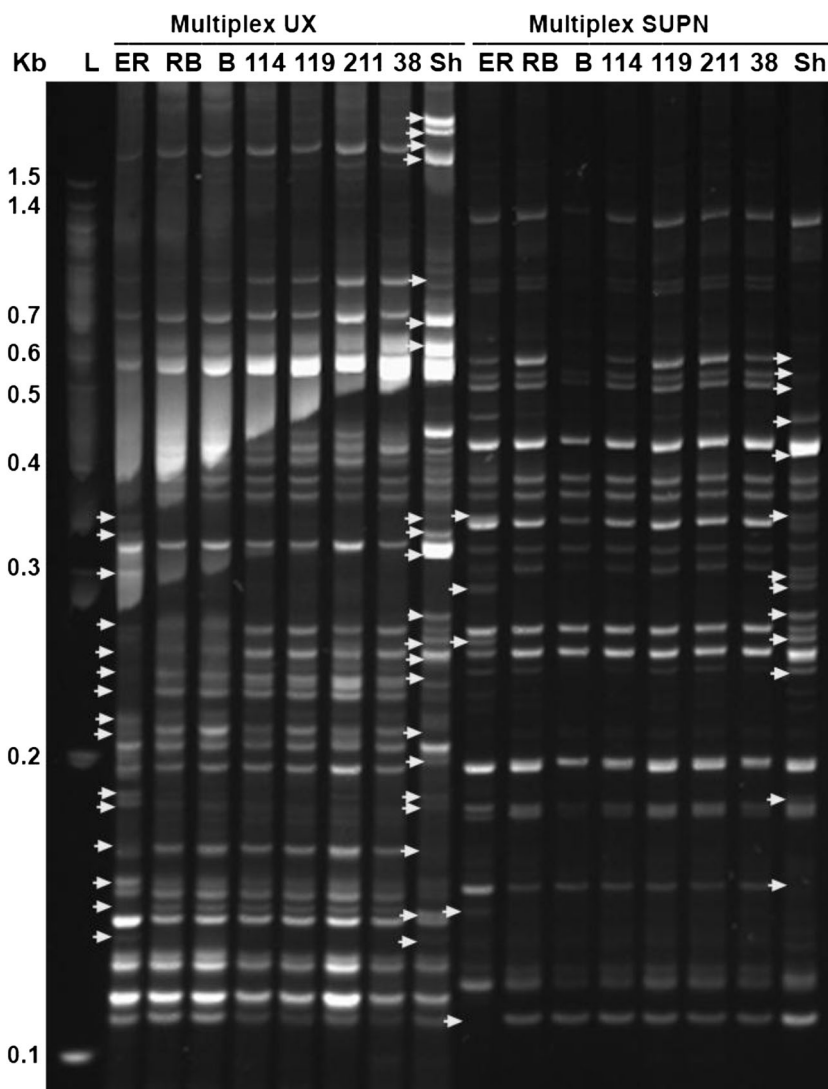
What of Russet Burbank? Could open-pollinated Burbank have led to a new hybrid? The possibility of self-set or outcrossed Burbank exists but is low as this cultivar is generally female and male-sterile (Douches et al. 1991). A comparison of isoenzyme patterns of Burbank and Russet Burbank showed the two were identical for 16 isoenzyme loci with 43 scorable allozymes (Douches and Ludlam 1991). All 112 cultivars and advanced breeding lines examined, including Early Ohio, a sibling of Burbank, were separable using this method except for line selections and sports that were indistinguishable from their original cultivar. Using a PCR-based DNA amplification method, with 16 arbitrary primers of 10 nucleotide length, 43 useful polymorphisms were tested for their ability to distinguish 45 North American cultivars and breeding lines (Sosinski and Douches 1996). Of the 16 primers, 10 discriminated all cultivars and only 4 were needed when tuber-grouping classification was used. The lowest frequency of polymorphisms between the cultivars examined, 1 out of 43 bands, was found between Russet Burbank and Burbank. The same authors distinguished 6 somatic lines of Russet Burbank from Russet Burbank by showing that they differed by 1 of 29 possible polymorphisms. These RAPD studies underline the small, random differences between Russet Burbank and Burbank, which are similar (1/43 bands) to the differences between Russet Burbank and six somatic lines derived from it (1/29 bands).

To further investigate the relationship between Burbank and Russet Burbank, the Multiplex polymerase chain reaction (PCR) system (Li et al. 2008) was employed at AAFC Potato Research Centre by Li and Haroon. This Multiplex system was capable of distinguishing all 116 cultivars registered in Canada at that time as well as several advanced breeding selections. The system uniquely distinguished 6 siblings and 34 half-siblings from each other and from their common parents (where tested). The Multiplex PCR system could not separate Russet Burbank from somatic lines derived from it (produced by Nassar et al. 2008) or Russet Burbank from Burbank although it readily distinguished Early Rose from all of these (Fig. 6). The Burbank and Russet Burbank group differs from Early Rose by at least 15 segments in the fingerprints produced by Multiplex UX and at least 5 segments in those produced by Multiplex SUPN (indicated by arrows). This considerable degree of difference between Burbank and Early Rose suggests that Burbank is unlikely to be a selfed progeny of Early Rose.

Recently, a set of diverse potato cultivars including Early Rose, Burbank, and Russet Burbank were genotyped using 8,303 single nucleotide polymorphisms (SNPs) distributed throughout the potato genome (Felcher et al. 2012; Hirsch 2013). Individual SNP loci were subjected to a series of quality control filters and SNP genotypes were called using either a diploid model with three marker classes (6373 SNPs) or a tetraploid model with five marker classes (3763 SNPs, Hirsch et al. 2013). Early Rose and Burbank showed 78.9 % identical SNP genotypes using the diploid model and 54.8 % identical SNP genotypes using the tetraploid model. At loci where SNP genotype calls were made in both cultivars, Early Rose and Burbank differed at 15.8 % of SNP loci using the diploid model and 36.5 % of SNP loci with the tetraploid model. Of the 15.8 % of SNP loci that differed between the two cultivars, over one third (344 of 1010 SNPs) were homozygous in Early Rose but heterozygous in Burbank. These data support the isoenzyme and Multiplex PCR data above as evidence that Burbank did not arise as a self of Early Rose. In contrast, Burbank and Russet Burbank had identical genotypes at 97.2 % of all SNPs using the diploid model and at 94.1 % of all SNPs using the tetraploid model. The extent to which this difference reflects genotypic rather than technical variation was not assessed. At loci for which a genotype call was made for both Burbank and Russet Burbank, no genotypic differences were observed between the two cultivars with the diploid model and only 0.7 % of SNPs differed with the tetraploid model. These data are consistent with the isoenzyme and Multiplex PCR data described above and strongly support the contention that Russet Burbank is a sport of Burbank and not a result of selfing or outcrossing of Burbank.

Mutation theory describes Russet Burbank as a classic example of a periclinal chimeral mutation affecting outer L_1 or L_1 and L_2 histogenic layers. A periclinal chimera is characterized as a stable arrangement with evolutionary advantage to retention of mutations in stratified apices of angiosperms (Kletkowski et al. 1985). The chimeral status of the NB Russet Burbank clone was tested over two field seasons with populations of intraclones produced from specific histogenic layers using somatic embryogenesis (Nassar et al. 2008). The tubers of all of these intraclones almost always had a russeted periderm, regardless of the histogenic layer from which they were derived. This was interpreted to mean that the genes for russet skin are present with similar incidence in all tissues of this clone regardless of the histogenic layer from which they are derived. While it cannot be proven that Russet Burbank was never a periclinal chimera, it is not currently organized in a periclinal chimeral arrangement. These results supported experimental observations of Clark (1930, 1933) who did not find evidence of periclinal chimeral structure in Russet Burbank based on an "eye excision" method. Clark suggested that Russet Burbank was probably a seedling of Burbank which is now ruled out on the basis of the evidence above.

Fig. 6 Genomic DNA fingerprints showing distinct pattern for Early Rose (ER), while patterns for Burbank (B) and Russet Burbank (RB) are similar. Genotyped by Li and Haroon from the AAFC-Fredericton Research Centre. Two multiplex PCR methods, Multiplex UX (Li et al. unpublished) and Multiplex SPUN (Li et al. 2008) were used with samples L: DNA ladder (BioLab100 bp); McGill University somaclones including 114: somaclone 14 from tuber histogenic layer L₁; 119: somaclone 19 from tuber histogenic layer L₁; 211: somaclone 11 from tuber histogenic layer L₂; 38: somaclone 8 from tuber histogenic layer L₃; Sh: Shepody. Arrows indicate the DNA segments in Early Rose that are different (present or absent) from Burbank and Russet Burbank



Garnet Chili has medium-deep eyes, inconspicuous short eyebrows, an irregular round shape, white flesh, and a bright reddish periderm (Fig. 2, Table 4). Early Rose has shallow to medium deep pink eyes, longer and slightly curved eyebrows, a round to more oblong shape, and white flesh that is occasionally streaked with red. Its skin has some russet features

and has been described as smooth but sometimes flaky and pink or brownish. Burbank eyes are more numerous and very shallow, the eyebrows short and inconspicuous, the tubers more cylindrical/blocky, the flesh is white, and the skin is very thin and white. Compared with Early Rose, Burbank has shallower eyes, longer tubers, and white thin skin. Early Rose

Table 4 Tuber characteristics of Russet Burbank and progenitors (Clark and Lombard 1946; and from specimens grown in NB, Canada 2006, 2013 see Fig. 2)

Cultivar	Eyes	Eyebrows	Flesh	Shape	Skin
Garnet Chili	Medium, magenta	Short, curved, inconspicuous	White	Medium, round to short oblong	Uneven dark red
Early Rose	Shallow, pink	Medium, slightly curved, medium prominent	White sometimes streaked red	Medium, round to long oblong, slightly flattened	Russet, uneven pink
Burbank	Numerous, shallow	Short, curved, inconspicuous	White	Large, long, cylindrical, or slightly flattened	Smooth, thin, white
Russet Burbank	Numerous, shallow	Short, curved, inconspicuous	White	Large, long, cylindrical, or slightly flattened	Russet, netted

is fertile while Burbank is male sterile. The Burbank phenotype has several recessive features according to previously proposed models: shallow eye depth and elongated tuber shape (Li et al. 2005), white thin skin (Jung et al. 2009), and male sterility (Gill et al. 1985). There is a very small chance of stacking 4–5 recessive traits through selfing. The phenotype data is certainly not in favor of a selfing model for the origin of Burbank from Early Rose (Fig. 2, Table 4).

Russet Burbank has all of the features of Burbank except the periderm is russet and more deeply netted than Early Rose (Fig. 2). Three independently segregating dominant loci are believed to be involved in the formation of russet skin based on genetic analysis of the russet trait in 22 progenies from cultivated diploid parents (De Jong 1981). We speculate that the smooth skin of Burbank could be explained if one of these loci was silenced or mutated. The reappearance of russet skin in Russet Burbank could have involved a loss of silencing, a second mutation, or movement of a transposon that restored gene function. This phenomenon would not be unique to Burbank and its sport, Russet Burbank. Maincrop, another white-skinned potato related to Early Rose, came to market in Great Britain in 1876. It produced a russet skinned sport called Golden Wonder in 1905 (Davidson 1935).

Contribution of Russet Burbank for Table Stock, Processing, and as Food

The replacement of Burbank by Russet Burbank occurred slowly. In 1930, 4 % of the U.S. crop was Russet Burbank (Smith 2011). Used for the dual purposes of fresh market and commercial frozen French fry processing (Darling 1968; CFIA 2013; PAA 2013a), Russet Burbank became and remains the most widely grown cultivar in the USA and Canada (Darling 1968; Atkinson et al. 2003; PAA 2013a). Its success was propelled by promotion by the railways (Fitch 1922) and the invention of frozen French fries in the US in the 1940's, the start of QSRs in the 1950's and the combined expansion of frozen French fry production and QSR for decades (Makki and Plummer 2005). Russet Burbank comprises approx. 70 % and 80 % of the potatoes used for this market sector in USA and Canada, respectively and is also grown for this market in the United Kingdom, Continental Europe and Australia/New Zealand (Leclerc, pers. com. 2013). In 2012, over 40 % of all potato growing area (450,000 acres; 182,109 ha) was planted to Russet Burbank in USA (USDA, NASS, 2013). Russet Burbank is also the most widely grown cultivar for the frozen French fry industry in Canada. If we estimate a similar proportion of the 371,713 acres planted to potato in Canada in 2012 (AAFC 2013), approx. 149,000 acres would be planted to Russet Burbank (including some for seed tubers).

Following decades of consumption of Russet Burbank as baked potatoes and French fries, consumers in North America and elsewhere have adopted Russet Burbank as the standard

for taste and other organoleptic properties. Traits that established Russet Burbank as the standard for the QSR franchises include high yield, high specific gravity, low oil absorption, narrow pith, low sugars, high recovery of excellent grade product, and long storability. These traits have been hard to improve on. It is the most studied potato cultivar in North America. Despite having a number of weaknesses, including late maturity, susceptibility to many diseases, knobby and off-type tubers resulting from water stress, and relatively low input use efficiency compared with more recent cultivars, it has proven extremely durable, due to excellent culinary and storage qualities.

Performance and Nutritional Quality of Russet Burbank and Burbank

As no comparisons of yield, taste, processing characteristics, or phytonutrient composition for Russet Burbank and Burbank were found by the authors, we compiled yield data based on control *ex vitro* plantlets used in studies of somaclones planted over three growing seasons from 2005–2007 and unpublished lab data from these tubers on processing and phytonutrient composition (Table 5). Yield, including total tuber weight and graded tuber weight (≥ 5 cm) (Kg), were similar over 3 years of field evaluation for plantlet-derived Russet Burbank and Burbank. Yield results of Early Rose were not available. In an informal taste test of cubed, microwaved samples, five of six participants could not distinguish Russet Burbank from Burbank, although one industry professional could always recognize Russet Burbank.

The processing characteristics including glucose (%), sucrose (mg/g FW), specific gravity, and French fry color of Russet Burbank and Burbank were similar (Table 5). Antioxidant scavenging activity of methanolic crude extract of tuber samples of Russet Burbank, Burbank, and Early Rose were evaluated using both the 2, 2'-azino-bis(3-ethylbenzo thiazoline-6-sulphonic acid) (ABTS) (hydrophilic phase) (Re et al. 1999) and 2, 2-diphenyl-1-picrylhydrazyl (DPPH) (Martínez-Valverde et al. 2002) methods (Table 5). The antioxidant scavenging activity of the hydrophobic phase was estimated using ABTS from a hexane extract of the same potato samples. For ABTS, Burbank and Early Rose showed greater antioxidant capacity compared to Russet Burbank while antioxidant scavenging activity using DPPH was similar among all three cultivars. Burbank had greater total phenolics (737.52 mg chlorogenic acid equivalent (CGAE)/150 g FW), based on the Folin-Ciocalteu method of Chirinos et al. (2007), and chlorogenic acid (67.97 mg/150 g FW), using the HPLC method of Shakya and Navarre (2006), compared to Russet Burbank (572.62 mg CGE and 41.39 mg/150 g FW, respectively). Ascorbic acid, caffeic acid, ferulic acid, and rutin

Table 5 LS Mean¹ results of total and graded (≥ 5 cm) yield (kg/plant); processing characteristics: glucose (%), sucrose (mg/g FW), specific gravity, and French fry colour; antioxidant activity: ABTS and DPPH; total phenolics; and phytonutrient content: ascorbic acid, chlorogenic acid, caffeic acid, ferulic acid, and rutin (μg or $\text{mg}/150$ g FM) of tubers of field-grown ex vitro plantlets of Russet Burbank, Burbank and Early Rose

Traits	Year	Russet Burbank	Burbank	Early Rose
Yield²				
Total Tuber Yield (Kg)	2005	1.74 ^a	2.46 ^a	NA
	2006	2.12 ^a	2.21 ^a	NA
	2007	0.90 ^a	1.41 ^a	NA
Graded Tuber Weight (Kg)	2005	1.36 ^a	1.76 ^a	NA
	2006	1.69 ^a	1.65 ^a	NA
	2007	0.77 ^a	1.20 ^a	NA
Processing Characteristics³				
Glucose (%)	2005	0.142 ^a	0.136 ^a	NA
	2006	0.139 ^a	0.089 ^a	NA
	2007	0.047 ^a	0.117 ^a	NA
Sucrose (mg/g FW)	2005	0.731 ^a	0.689 ^a	NA
	2006	1.641 ^a	1.419 ^a	NA
	2007	0.938 ^a	0.780 ^a	NA
Specific Gravity	2005	1.085 ^a	1.082 ^a	NA
	2006	1.094 ^a	1.093 ^a	NA
	2007	1.071 ^a	1.077 ^a	NA
French Fry Colour (Agtron Units)	2005	78.0 ^a	84.0 ^a	NA
	2006	77.8 ^a	99.3 ^a	NA
	2007	93.6 ^a	83.5 ^a	NA
Antioxidant Activity and Phytonutrient Contents⁴				
ABTS ($\mu\text{g}/150$ g FM Trolox Equ.)		1655.74 ^b	2696.05 ^a	2877.95 ^a
DPPH (mg/150 g FM Gallic Acid Equ.)		149.29 ^a	149.72 ^a	151.21 ^a
Total Phenolic (mg/150 g FM CGAE)		572.62 ^b	737.52 ^a	713.37 ^{ab}
Ascorbic Acid (mg/150 g FM)		93.82 ^a	147.38 ^a	106.09 ^a
Chlorogenic Acid (mg/150 g FM)		41.39 ^b	67.97 ^a	55.29 ^{ab}
Caffeic Acid (mg/150 g FM)		3.18 ^a	11.48 ^a	7.74 ^a
Ferulic Acid (mg/150 g FM)		0.55 ^a	1.27 ^a	1.60 ^a
Rutin (mg/150 g FM)		3.49 ^a	4.50 ^a	2.90 ^a

¹ LSMeans were compared using Tukey's Studentized Range (HSD) Test. Superscripts not sharing the same letter for each crop or number for differences between crops are significantly different ($P \leq 0.05$) using the Statistical Analysis System (SAS) (SAS 2009)

² n=40 plants (plantlet-derived) in 2005 and 10 plantlets in 2006 and 2007

³ n=3 replicates each of at least 10 tubers

⁴ n=3 replicates each of 3–5 homogenized tubers

Table 6 LS Mean values for macro (Ca, K, Mg, Na, and P) and trace (Cu, Fe, Se, and Zn) minerals in one serving (mg/148 g FW) from Russet Burbank grown at different Canadian sites: Alberta (AB), Manitoba (MB), New Brunswick (Bon Accord; (BA) and Florenceville (FL)), and Quebec (QC)

Site	DM (%)	Ca	K	Mg	Na	P	Cu	Fe	Se	Zn
BA	19.51	44.95 ^a	1897.5 ^a	127.0 ^a	3.81 ^b	335.6 ^a	0.69 ^{ab}	6.10 ^a	41.05 ^a	1.40 ^a
AB	25.14	37.67 ^a	2224.5 ^a	161.4 ^a	18.93 ^a	381.2 ^a	0.88 ^a	5.19 ^a	0.48 ^b	1.48 ^a
MB	22.48	43.03 ^a	2046.3 ^a	140.7 ^a	5.59 ^b	301.5 ^a	0.45 ^b	4.80 ^a	ND	1.79 ^a
FL	23.38	35.00 ^a	2061.4 ^a	148.7 ^a	2.41 ^b	370.6 ^a	0.88 ^a	3.82 ^a	18.82 ^a	1.89 ^a
QC	21.70	44.27 ^a	1684.0 ^a	114.0 ^a	4.39 ^b	268.7 ^a	0.57 ^b	5.00 ^a	ND	1.83 ^a

Means were compared using Tukey's honest significant difference test ($p \leq 0.05$); n = 5–10 replicates. Means with the same superscript letter are not significantly different. Superscript letters label differences between Russet Burbank from different growing sites

levels (HPLC) in mg/150 g FW were the same in the three cultivars.

Macro and micro mineral contents of Russet Burbank were estimated at five growing sites in Canada (Alberta, Manitoba, New Brunswick (two sites, Bon Accord and Florenceville), and Quebec) and showed remarkable stability (Table 6) (Nassar et al. 2012). Similar content occurred for almost all minerals across sites, except sodium (greatest at Alberta), selenium (least at Alberta and not detected at Manitoba and Quebec), and copper (least at the Quebec site). As a percentage of recommended daily intake (RDI), a consumer who eats one serving (148 g FW) of Russet Burbank tubers per day could receive up to 4.5 % of calcium, 64 % of potassium, 46 % of magnesium, 0.79 % of sodium, 38 % of phosphorous, 44 % of copper, 41 % of iron, 20 % of selenium, and 10 % of zinc (Table 6).

The Next Century for Russet Burbank and its Ancestors

This centenary project to highlight the PAA's first 100 years and activities of its members clarifies the origins of Russet Burbank and its progenitors; among the most important cultivars in potato breeding history. The relative importance of Rough Purple Chili, Garnet Chili, Early Rose, and Burbank as major contributing ancestors to North American potato cultivars underlines the need to correct misconceptions regarding their origins. The commercial and cultural importance of Russet Burbank requires that a complete account of its origin be made available. A goal of this effort is that descriptions of Russet Burbank's lineage and origins will be corrected by seed companies, in lists of potato cultivars, and at world repositories holding Russet Burbank and its progenitors. In North America, this will include CFIA, Plant Gene Resources Canada GRIN-CA, and GRIN-USDA-Sturgeon Bay.

There are relatively few germplasm holdings in world repositories of the original cultivar Burbank, which is undergoing thermotherapy and meristem tip culture for elimination of PVS at USDA-Sturgeon Bay and is PVX-infected at the INRA repository in France. Garnet Chili and Early Rose have fared better, but Rough Purple Chili and numerous other important nineteenth and early twentieth century cultivars have been lost. Heritage cultivars, such as these, are important to maintain even as economic stresses force the consolidation of plant germplasm resources around the world.

The young Luther Burbank was the originator of Burbank and by default, the variant Russet Burbank, now over 100 years in cultivation. Burbank went on to become one of the earliest, most prolific and controversial plant breeders ever known; only recently have his accomplishments been rediscovered (Stansfield 2006). He is credited with introducing between 800

and 1,000 plants to American horticulture. Ironically, his most celebrated and enduring introduction was his first.

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