Luther Burbank's Best Berries

Kim E. Hummer¹

USDA-ARS National Clonal Germplasm Repository, 33447 Peoria Road, Corvallis, OR 97331-2521

Chad E. Finn

USDA-ARS Horticultural Crops Research Unit, 3420 NW Orchard Avenue, Corvallis, OR 97330

Michael Dossett

Agriculture and Agri-Food Canada–Pacific Agri-Food Research Centre, 6947 Highway #7, P.O. Box 1000, Agassiz, British Columbia V0M 1A0, Canada

Additional index words. blackberries, genetic resources, Fragaria, germplasm, raspberries, Rubus, small fruit, grape, blueberry, Solanum

Abstract. Luther Burbank, the quintessential nurseryman of the early 20th century, remarked that small fruit was the "Cinderella of the pomological family." He stated that although tree fruits had been improved to the point of an almost uncountable number of cultivars, it was the time and responsibility of his generation and those to follow to develop the small fruit for human consumption. Burbank had a penchant for detecting potential qualities of unusual plants and his broad association with plant explorers at the U.S. Department of Agriculture and elsewhere allowed him to examine diverse wild berry species. He obtained seeds of many small fruit species from throughout the world. He made wide crosses within and between these genera and species. Burbank selected and named many cultivars to be introduced through his nursery and elsewhere. He named and released ~40 blackberries, raspberries (*Rubus* L.), and strawberries (*Fragaria* L.); four grapes (Vitis L.); and a hybrid Solanum that he named 'Sunberry'. He sometimes exaggerated their descriptions for promotion or public recognition. For example, Rubus × loganobaccus 'Phenomenal' was, he stated, "far superior in size, quality, color, and productivity..." to 'Loganberry'. Unfortunately, this cultivar was not a commercial success. Burbank made a few crosses and sold what he considered to be improved species, e.g., 'Himalaya Giant' blackberry (R. armeniacus). He created new common names for foreign species, e.g., balloon berry (R. illecebrosus) and Mayberry (R. palmatus), to better market them. However, his amazingly keen observations of thornlessness, pigment diversity, and recognition of repeat flowering and fruiting in blackberries, raspberries, and strawberries, were insightful of the needs of future industry. Burbank was a disciple of Darwin and his theory of natural selection. Burbank's classic breeding approach, to make wide crosses, produce large numbers of hybrid seedlings, choose significant seedlings with his traits of choice, and backcross to the desired parent for several generations, was successful, although he did not know of ploidy or gene recombination. Unfortunately, the 'Himalaya blackberry', now ubiquitous in hedgerows and fields throughout the Pacific Northwest in the United States, is designated as a federal noxious weed. Although not presently in commercial production, three of his Rubus cultivars ('Burbank Thornless', 'Snowbank', and 'Phenomenal') are preserved in the U.S. Department of Agriculture, National Clonal Germplasm Repository, in Corvallis, OR.

"The successful plant developer must be able to look beneath the surface of his [her] plants to discover and utilize the underlying harmonies."—Luther Burbank (Burbank, 1914)

Luther Burbank (7 Mar. 1849 to 11 Apr. 1926) was an amazingly charismatic person with a reputation as the plant "wizard." He referred to himself as a "plant inventor," the equivalent in horticulture to what his friends and colleagues, Thomas Edison and Henry Ford, were in engineering.

Burbank was a focused plant breeder. He had a combination of rough-cut, dirt-underthe-fingernails knowledge of a horticulturist and the sharp eyes of a plant breeder who could instantly delineate the smallest difference in the color of a petal or width of a stem. He was so vigorous and energetic in selecting plants that his helpers could hardly keep up (Howard, 1945). His business strategy was to produce novel plants and sell them outright to plant

HORTSCIENCE VOL. 50(2) FEBRUARY 2015

nursery brokers such as John Lewis Childs and others. This allowed him to continue his favorite work: breeding and selection.

Although long-term recognition came from significant cultivar releases in many crops, he had a fondness for berries, calling them the "Cinderella of the pomological family." He made many forays into the development of berries from wild species from around the world. He educated and encouraged other breeders and nursery people to improve small fruits (Burbank, 1914). Burbank loved children and welcomed the opportunity to teach them about nature and the plant world. The breeding narratives of his 12-volume book, "Luther Burbank: His Methods and Discoveries and Their Practical Application" (Burbank, 1914), are intermingled with tales about and for children. He bred plants for the future of humankind.

Burbank was inspired by Darwin and became a literal disciple of his theory of variation of species and natural selection. Burbank realized that plants in nature were not fixed and could be manipulated by humans for improvement and use. Burbank's breeding protocol was to make wide crosses, including unusual intergeneric ones such as apples with blackberries or strawberries with raspberries. Next he produced millions of hybrid seedlings. With such great numbers of offspring, he then selected only a few having his traits of choice and discarded the remainder. He had only 20 acres of land including both his Santa Rosa and Sebastopol, CA, farms (Smith, 2009), so if seedlings did not perform, they were quickly pulled and burned. He backcrossed seedlings with desired traits to the parent for several generations, focused on his specific breeding objectives, and culling the rest (Howard, 1945). This recurrent selection proved successful with a broad array of plant genera, although Burbank had no clear knowledge of chromosomes, ploidy, or gene recombination. Not understanding genetics or mutation, he denied Mendel's theory throughout his career, although his results were supportive.

This article has two objectives. The first is to broadly summarize Burbank's work on small fruit and berry crops. The second is to emphasize his efforts on *Rubus* including his development of thornlessness, pigment mutation, and interspecific crosses. In addition, Burbank's efforts will be integrated into current work on small fruit and berry breeding and genetics.

BURBANK'S BERRIES

Howard (1945) described Burbank's life work and compiled a summary of his releases.

Approximately 60 berry crop releases are noted (Table 1). In this article, we take a broad approach of this to include not only the

Received for publication 15 July 2014. Accepted for publication 7 Aug. 2014.

This paper was part of the workshop "Contributions of Luther Burbank: Plant Breeding Artist and Legend" held 22 July 2013 at the ASHS Conference, Palm Desert, CA, and sponsored by the ASHS History of Horticultural Science Working Group. ¹To whom reprint requests should be addressed; e-mail Kim.Hummer@ars.usda.gov.

Table 1. Number of named small fruit and berry cultivars, grouped by crop type, released by Luther Burbank (tabulated from Howard, 1945).

Crop	Number	Crop	Number
Blackberries	16	Buffaloberry	1
Raspberries	13	Cape Gooseberry	1
Strawberries	10	Elderberry	1
Dewberries	4	Gooseberry	1
Grapes	4	Juneberry	1
Sunberry	3	Mulberry	1
Blueberries	2	Salmonberry	1



Fig. 1. Heart-shaped fruit of an unnamed strawberry cultivar. Image adapted from that in Burbank (1914).

horticultural small fruits, but a few botanical "berries" that Burbank worked on as well. Although Burbank mentions many additional species importations and crosses (Burbank. 1914), he did not maintain detailed written notes. When asked about pedigrees, he could verbally describe the parents because he recognized species and hybrids through traits. He did not keep a written log of his crosses nor were his crosses controlled in the sense of exclusion of unwanted pollen. He did not care as much about ensuring the occurrence of a specific cross, so he did not use cages; rather, he kept focused on the outcome of his breeding objectives. He selected one plant that matched his vision, with the right combination of traits, out of thousands of undesirable siblings.

His friend, U.S. Department of Agriculture (USDA) plant explorer David Fairchild, as well as many other contacts throughout the world, provided him with seeds of unusual small fruits (Burbank, 1914; Fairchild, 1944). He imported particularly unusual species from all around the world so that diversity was as broad as possible. He then performed intergeneric, interspecific, or other unusual crosses to obtain novel berries never seen before. The many sterile and undesirable seedlings were discarded at the earliest opportunity so that those of the next cross could take their place.

Strawberry

Burbank appreciated the diversity of strawberry species. He was unaware of ploidy levels, but obtained wild species from the United States and elsewhere to make broad crosses. Most of these crosses were not attempted anywhere before his efforts. Unfortunately, many produced non-fertile offspring. For example, he crossed *Duchesnea indica*, a plant with a similar appearance to strawberry but with yellow petals and inedible



Fig. 2. 'Sunberry' fruit. Image adapted from that in Burbank (1914).

red fruits, with the common cultivated strawberry. No viable offspring were produced (Howard, 1945). Others have confirmed these results (Hughes and Janick, 1974).

Burbank discussed nature with a group of school children. He talked about seeds being the link between successive generations. To bring the illustration home, Burbank said that the seed is the very "heart" of the plant (Fig. 1). One youngster replied, "Then the strawberry wears its heart on its sleeve." Burbank liked that analogy. He remarked in his book (1914) that the ultimate of strawberry perfection would be seedlessness. He recognized that many clonally propagated crops such as banana, horseradish, pineapple, and even potatoes to an extent have eliminated or reduced seed production. Strawberries commonly propagate vegetatively by runners so that Burbank had no doubt that strawberry seeds could be eliminated through breeding once the perfect strawberry had been produced (Burbank, 1914).

Burbank made many wide crosses with strawberries. He crossed Chilean strawberries (species or forma unnoted) with the major strawberry cultivars of his day: 'Brandywine', 'Monarch', and 'Marshall'. He raised more than 500,000 strawberry seedlings in 40 years (Burbank, 1914). Although there were many seedlings of "a high order," each had imperfections that could be improved. Burbank discussed broadening the gene pool for the cultivated strawberry, defining a task continued by today's scientists and breeders. In fact, Hancock et al. (2010) are "reconstituting" the strawberry genome with wild collections from North and South America.

One of Burbank's breeding objectives was to get "a strawberry to bear the year around." Remontancy, or continuous blooming and fruiting, was one of his breeding objectives for strawberries. Regrettably, Burbank's explanation of continuous bloom in strawberry was conjecture rather than understanding. He described how the new hybrid strawberry combined ancestral strains from two hemispheres, North and South America. Thus, to him this was an illustration of the tendency for parents from both hemispheres to contribute summer bearing habit to produce a perpetual bearing trait in the seedlings (Burbank, 1914). Burbank did not live to see the development of remontant strawberries, but modern day-neutral cultivars that bloom throughout the growing season are a fulfillment of Burbank's vision and have proven invaluable to the industry. Burbank named 10 strawberry cultivars, although none have survived (Howard, 1945).

Grape

Burbank's efforts with Vitis species focused on table grape development. Burbank (1914) estimated that over 40 years he probably raised $\approx 100,000$ seedlings from crossing the best table grape cultivars. He hybridized many genotypes including European and American and cultivated and wild. He also imported many wild species from Svria, Mexico, Australia, China, and Japan. Burbank released five grapes: four grape cultivars and one species introduction (Howard, 1945). Several were seedlings of 'Pierce', a sport of 'Isabella'. Burbank's goals were productivity, fruit size, pigments (including white, yellow, red, and purplish black), flavor, season, and seedlessness.

Blueberry

Burbank did not release any highbush blueberries (Vaccinium corymbosum); that achievement is credited to Dr. Frederick Coville, USDA plant breeder in Beltsville, MD. Burbank brought highbush blueberry to California and planted it in his yard. Burbank recognized that highbush blueberry could be selected for warmer climates and predicted that blueberry could be grown for production in California. Burbank brought in a species of blueberry from South Africa (likely to have been Vaccinium exul) and crossed it with the "coastal blueberry" (likely to be V. ovatum); both of these are diploid species. No hybrid cultivar survives today from this cross. Blueberries have now achieved major world status and are an important crop in California with a value of over \$133 million.

Sunberry

Burbank was the subject of many controversies during and after his lifetime, but one of his creations, the 'Sunberry', or 'Wonderberry', caused particular disagreements. Although Heiser (1987) stated that Burbank himself gave different accounts of the origin of his 'Sunberry', Burbank claimed in his book, volume 6 (1914), that his 'Sunberry' (Fig. 2) was a product of more than 20 years

Downloaded from https://prime-pdf-watermark.prime-prod.pubfactory.com/ at 2025-07-05 via free access

of crosses. Burbank described that he crossed the great African stubble-berry, Solanum guinense, and the little downy nightshade S. villosum many times. In 1905, a few seedlings from this cross that sprouted in the greenhouse were different. As the plants came to maturity, one seedling flowered and fruited quite abundantly (Burbank, 1914). The fruit was intermediate in size between the two parents but the quality was quite different from either. Rather than the vile-tasting fruit of S. guinense or the insipid fruit of the S. villosum, Burbank selected fruit from the offspring that excelled in "profusion, size, and flavor." He took the seed and multiplied them rapidly to produce two crops in a single season. He checked that the traits that he desired were "fixed" and gave the name 'Sunberry' to what he said was the F_2 of Solanum villosum \times S. guineense.

Burbank was not in control of the cultivar after he sold it to John Lewis Childs. Childs changed the name to 'Wonderberry' and marketed it with superlatives including: "Luther Burbank's greatest and newest production. Fruit blue-black like an enormous rich blueberry. Unsurpassed for eating...in any form. The greatest garden fruit ever introduced.... Easiest plant in the world to grow, succeeding anywhere and yielding great masses of rich fruit." Because some customers interpreted the plant as being a selection of the common nightshade. Solanum nigrum, with inedible or even poisonous fruit, an anti-'Wonderberry' movement was started. Herbert W. Collingwood, president and editor of *The* Rural New Yorker, was vocal in the movement. Heiser (1987) describes the controversy in detail, including how Burbank accused Childs of distributing the common "huckleberry" (nightshade) as the 'Wonderberry'.

Heiser describes how Jorge Scoria, a graduate student at Indiana University, replicated the cross that Burbank had described and said that he had made. Now we know that Solanum guineense is hexaploid (2n = 6x = 72), whereas Solanum villosum is tetraploid (2n =3x = 48). Because of the chromosome inequality, a sterile pentaploid offspring might be expected; however, Scoria observed no offspring. He considered that Burbank may have misidentified S. villosum. Heiser noted that Burbank's written description of S. villosum also did not match the species. Burbank may have used S. sarrachoides, a diploid (2n = 2x =12) South American species that had been in California at that time.

Heiser crossed S. guineense and S. sarrachoides and obtained hybrids. These plants did not resemble pressed specimens of Burbank's 'Sunberry', although they produced seeds, so Heiser came to conclude that Burbank had not made the cross that was described.

Heiser heard about a Solanum called "msoba" grown in South Africa and ordered some seed from Gleckler's Seedmen of Metamora, OH. Information from Gleckler indicated that Burbank's 'Sunberry' was very much like the South African msoba with silver leaves and bluish berries. After growing this species from seed, Heiser (1987) gives two possible conclusions: the msoba may have been ancestor to the 'Sunberry' or vice versa. New plant samples made the former hypothesis seem more likely. This new information from South Africa led Heiser to conclude that the 'Sunberry' was definitely not black nightshade, Solanum nigrum; neither was it the hybrid that Burbank claimed. Whatever the derivation, the 'Sunberry' did not become a wide success in America or Europe, but this Solanum, or something very similar, is likely to be under cultivation in South Africa.

Rubus

Burbank was drawn to the simplicity of rosaceous flowers, including those of the plums, apples, peaches, pears, and mountain ash. He was especially intrigued with Rubus-raspberries, blackberries, and their relatives where he made wide crosses between species and between different crop groups. He examined and crossed many wild Rubus species (Table 2). He imported and improved what he called "races" of little known exotic species and sold many berry genotypes for cultivation in the United States. He brought in R. hawaiiensis from Hawaii, R. idaeus var. strigosus (American red raspberry) from Alaska, and many species from Asia, South Africa, Europe, and India. He created new common names for foreign species, e.g., balloon berry (R. illecebrosus) and Mayberry (R. palmatus), to better market them.

Burbank made good use of American raspberry species including the American black raspberry species, R. occidentalis of eastern North America, and its counterpart, R. leucodermis, native west of the Rocky Mountains. He also used the North American red raspberry, R. idaeus var. strigosus, in his crosses. He released 13 red, black, and purple (black \times red) raspberry cultivars along with making broader crosses within the genus (Table 3).

Blackberry

In the 1880s Burbank imported blackberry seeds from India. He was unaware at the time that this was a European blackberry, R. armeniacus, which had been introduced into India. He grew the blackberry seedlings, made a few crosses, selected for large fruit and thornlessness, and sold what he considered was an improved species, e.g., 'Himalaya Giant' blackberry. He was not likely aware that R. armeniacus was pseodogamously apomictic and many of his crosses were likely in vain. Burbank released this blackberry clone with the best of intentions, but unfortunately it has become a noxious weed throughout Pacific Northwestern North America (McConahey, 2006). Birds enjoy eating the fruit and have ensured plant distribution along the West Coast. This blackberry has great genetic variability (McConahey, 2006). Seed of thornless, highly productive clones produced plants that vary in thorniness and productivity and have become invasively distributed throughout the Pacific Region. The thorny types appear to be the most vigorous.

Thornlessness. Burbank was quite excited about finding and selecting for thornlessness in blackberries. He predicted that the children of the next generations would be blissfully ignorant about thorny blackberries because of the introduction of the thornlessness. He invoked children's stories and poems about thorny briars and explained that this poetry would not be applicable in the future (Burbank, 1914). He was certain that his thornless types would be so popular as to take over the market. Although clonal propagation can maintain the genetic thornless mutants, seedlings will be predominantly thorny.

Species	Species group/common name
R. allegheniensis Porter	Eastern American erect blackberry
R. coreanus Miq.	Korean black raspberry
R. armeniacus, R. procerus, R. discolor	European blackberry, Himalaya(n) blackberry
R. canadensis L.	Northeastern erect blackberry
R. chamaemorus L.	Cloudberry
R. crataegifolius Bunge	Siberian berry, Asian raspberry
R. deliciosus Torr.	Rocky Mountain raspberry
R. hawaiiensis A. Gray	Hawaiian raspberry
R. idaeus L.	European red raspberry
R. illecebrosus Focke	Balloonberry, strawberry raspberry
R. laciniatus Willd.	Evergreen blackberry, cut-leaf blackberry
R. leucodermis Douglas ex Torr. & A. Gray	Western black raspberry
R. loganobaccus L.H. Bailey	Hybridberry, Loganberry, Boysenberry
R. ×neglectus Peck	Purple raspberry
R. occidentalis L.	Eastern black raspberry
R. odoratus L.	Flowering raspberry
R. palmatus Thunb.	Mayberry, Japanese raspberry
R. parviflorus Nutt.	Thimbleberry
R. phoenicolasius L.	Wineberry
R. pileatus Focke	Asian raspberry
R. rosifolius Sm.	Cape bramble, Mauritius raspberry
R. spectabilis Pursh	Salmonberry
R. strigosus Michx.	American red raspberry
R. trivialis Michx.	Southeastern trailing blackberry, dewberry
<i>R. vitifolius</i> Cham. and Schldtl. = <i>R. ursinus</i> Cham. and Schldtl.	Western trailing blackberry, California dewberry

				Extant
Crop	Cultivar name	Pedigree	yr	in 2014
Blackberry	Himalaya = Himalaya Giant	$F_2 R. armeniacus$	1885	Yes
	Autumn King	Lawton × Oregon Everbearing	1893	No
	Iceberg	F_3 (Crystal White × Lawton)	1894	No
	Red Hybrid Blackberry	Similar to Loganberry but larger and better quality.	1897	No
	Triumph	Unknown	1914	No
	Snowbank	Seedling of Iceberg	1916	Yes
	Superb	Seedling of Himalaya Giant	1916	No
	Santa Rosa	R. armeniacus selection (thornless blackberry)	1920	No
	Sebastopol	R. armeniacus selection (thornless blackberry,	1920	No
	-	like above but later season and sweeter)		
Hybridberry (blackberry × raspberry)	Paradox	F_4 (Crystal White × Shaffer's Colossal raspberry)	1893	No
	Primus	R. ursinus \times R. crataegifolius	1893	No
	Phenomenal	Aughinbaugh \times Cuthbert (raspberry)	1893	Yes
	Cultivar synonyms = Hybrid 18234 Humboldt		1909	
	Climax	Sibling of Phenomenal	1914	No
Raspberry	Mendocino	Selection of wild R. leucodermis	1887	No
(includes blacks and reds)				
	October Giant	Seedling of Eureka (large, primocane-fruiting black raspberry)	1893	No
	Eureka	F_3 (Gregg × Shaffer)	1893	No
	Hybrid E. 11,546	F_3 (Souhegan × Gregg)	1893	No
	Hybrid S.S 147	F_3 (Shaffer × Souhegan)?	1893	No
	Hybrid S.S. 6701	F_3 (Souhegan × Gregg)?	1893	No
	Japanese Golden Mayberry	Yellow selection of R. palmatus	1893	No
	Dictator	Gregg × Shaffer	1897	No
	Sugar Hybrid	F_2 (Shaffer × Souhegan)	1893	No
	Rubus	Selection of <i>R. capensis</i> (synonym for <i>R. rosifolius</i>)	1894	No

In Burbank's time, the objective of thornlessness was primarily of interest so that gardeners and commercial growers would be able to manage and manipulate the plant with less risk of personal injury. However, with the advent of the regular use of machine harvesters to harvest blackberries in the 1960s and 1970s, thorn contaminants in the harvested product became a serious issue. Although thorns may have just been a nuisance in the 1970-80s, they became a major focus of lawsuits in the 1980-90s. Consumers who say they were injured by thorns in processed berry product sometimes have resorted to litigation. Therefore, thornlessness is a major objective of blackberry breeding programs.

The first commercially important thornless blackberry was 'Thornless Evergreen', a sport of 'Evergreen' released \approx 1926. The first commercially important thornless blackberries released to meet modern standards of fruit quality were 'Navaho', released for the fresh market in 1989, and 'Black Diamond', released in 2005, for the machine-harvested, processed fruit market.

White-fruited Rubus. Burbank assumed the challenge of developing a "truly white blackberry" without understanding the genetic background. Pure white blackberries were not recorded previous to his breeding efforts. Even today light-colored, i.e., yellow, mutants in *Rubus* occur but are infrequent across species with higher ploidy (Jennings, 1988).

Yellow color forms are not uncommon in diploid *Rubus* species and are documented in the raspberries, *R. idaeus*, *R. occidentalis*, and *R. phoenicolasius* and the blackberries, *R. trivialis* and *R. allegheniensis* (Jennings, 1988). Many light-colored *R. allegheniensis* have since been patented, including types such as 'Nettleton's Creamy White' (U.S. Plant Patent 20,234), which, although patented as a *R. fruticosus*, is a *R. allegheniensis* selection. However, colorless mutants in tetraploid or higher ploidy *Rubus* have not been reported (Jennings, 1988).

Light fruit color in Rubus is a recessive mutation, a "knockout" function of the anthocyanin pathway (Lee et al., 2012). For a white fruit to occur in tetraploid blackberries, all four loci would need to have mutated. Because mutations by their very nature are uncommon, inbreeding would be required for the complete homozygous recessive condition. In the case of a tetraploid, that means that only a 6.25% chance that any yellow-fruited seedling will occur from a parent carrying one copy of the mutated gene. With possible inbreeding depression in the early generations, such an occurrence at any of the higher ploidy levels is exceedingly rare unless it is deliberately selected for over several generations.

Many of the commonly seen pigment mutations in *Rubus* are orthologous, i.e., genes that have similar function for different species as in *R. phoenicolasius* and *R. idaeus*, but other mechanisms exist. The level of fruit flesh and skin color depends on where the pigment production pathway is disrupted (Lee et al., 2012). Lee et al. (2012) detected very low levels of cyanidin-3-glucoside and cyanidin-3-rutinoside in yellow forms of *R. occidentalis*, but the total anthocyanin concentration was less than 1% of normal. Red raspberry has a well-known common

mutation that produces amber/orange-colored fully ripe fruit (ppTt). This, in combination with another, much less common mutation, produces a much lighter yellow and less orange-colored fruit (pptt). The orange-fruited form likely has low levels of anthocyanins similar in type to those of the black raspberry, whereas the other is completely devoid of them. Other chemicals produced in the fruit can provide a yellowish color even without any anthocyanins. The structure of the drupelet skin and its contents may mean that some are likely to be more translucent than yellow, but none are truly white.

Burbank mentioned that his white blackberry produced translucent drupelets, and the whitish cast was likely attributable more to glare off the drupelet surface reflecting light than from white pigment. For plants that have a chlorophyll deficiency, their leaves produced little or no chlorophyll and the unripe fruits, instead of being greenish as normal, were almost whitish. As the fruit ripened, they became nearly translucent and then accumulated some anthocyanins near the end of ripeness. Their translucence was likely a structural quality not seen in raspberry species, even when the same pigment genes were knocked out in blackberry.

Burbank described 'Crystal White' (Fig. 3) as having semitranslucent fruit with a yellowish tint. He said that he improved the fruit quality by crossing with 'Lawton' and then selected recombinants with less color. These statements are likely true, but the intriguing part is that 'Lawton' (Fig. 3) is a tetraploid, and 'Crystal White' and 'Snowbank' (Fig. 4) are diploids (Meng and Finn, 2002;





Fig. 4. (A) 'Iceberg' image adapted from that in Burbank (1914), and (B) 'Snowbank' blackberry fruit, photo credit to Rachael Spaeth of Luther Burbank Home and Gardens, Santa Rosa, CA.



Fig. 3. (A) 'Crystal White'(diploid) and (B) 'Lawton' blackberry (tetraploid) fruit. Image adapted from that in Burbank (1914).

Thompson, 1995). His 'Crystal White' \times 'Lawton' hybrids were likely to have been triploid with only a few tetraploids. He probably observed much more sterility than he mentions in his description, which merely says that they "were black." He described a few white-fruited types in the F₂ generation, as would be expected. 'Snowbank' is based on further crossing and selection from within this group. He was likely able to select recombinants that had less pigment, but probably had to produce huge populations to get these few.



Fig. 5. 'Phenomenal' fruit. Image from that in Burbank (1914).

'Snowbank' is diploid, so the probability of obtaining two homozygous recessive white mutant alleles is greater than for a tetraploid plant. The F₁s may have been triploids with two sets of chromosomes from 'Lawton' and one from 'Crystal White'. Then, in the F₂ generation, Burbank selected diploid recombinants that inherited two copies of the recessive mutation from 'Crystal White', whereas the third set of chromosomes dropped out during meiosis. This would have resulted in a white-fruited diploid like 'Crystal White', but with genetic contributions for improved fruit quality from 'Lawton'. Unfortunately, 'Iceberg', an offspring of 'Snowbank', no longer exists.

Hybridberry—Blackberry × raspberry

Since the 1883 discovery of 'Logan' (synonym = 'Loganberry'), by Judge James Logan of Santa Cruz, CA (Jennings, 1988), many *Rubus* breeders were interested in making blackberry by raspberry crosses.

'Logan' came from a cross of the octoploid R. *ursinus* 'Aughinbaugh' × diploid R. *idaeus* 'Red Antwerp' and is a hexaploid with 42 somatic chromosomes (Jennings, 1988). 'Logan' is likely the result of an unreduced pollen grain of the red raspberry that fertilized the octoploid blackberry.

Burbank also was interested in this type of cross. He crossed 'Aughinbaugh' with *R. idaeus* 'Cuthbert' to produce a second-generation seedling he called Hybrid berry V.C. 18,234, subsequently renamed 'Humboldt'. This clone was then sold to John Lewis Childs, renamed, and marketed as 'Phenomenal' in 1894. 'Phenomenal' proved to be Burbank's best-known berry cultivar (Fig. 5). He described it as "far superior in size, quality, color, and productivity..." to 'Loganberry'. Despite Burbank's claim, this cultivar was not as much of a commercial success as 'Logan' (Jennings, 1988).

'Phenomenal' became of interest to B.M. Young of Morgan City, LA. Young obtained plant material from Burbank and made a cross with the hexaploid 'Phenomenal' and the octoploid, Rubus baileyanus \times R. argutus 'Austin Mayes'. The result was 'Young' (synonym = 'Youngberry'), a berry that was introduced in 1926 and rapidly became popular for its excellent flavor and large fruit. The fruit color is maroon, and the flavor is sweet. 'Young' was a parent of 'Olallie' and is in the pedigree of 'Marion', 'Silvan', and many other cultivars in the Oregon blackberry breeding program. Burbank's cultivar Phenomenal has contributed to more than 2400 ha of blackberries planted in the United States. 'Young' is also grown in New Zealand although it is marketed under 'Boysen' (H. Hall, personal communication).

CONCLUSION

Of the crops of plants bred and released by Burbank, his small fruit genotypes have had less direct economic impact on the present commercial production than that of his potato or ornamental flowers such as the 'Shasta' daisy, yet his blackberries and hybrid berries, 'Burbank's Thornless', 'Snowbank', and



Fig. 6. Image of Luther Burbank selecting *Rubus* seedlings. Image adapted from that in Burbank (1914).

'Phenomenal', remain available through genebanks (at Sebastopol and Santa Rosa, CA, and the USDA-ARS National Clonal Germplasm Repository, Corvallis, OR), and these cultivars continue to have an impact on world berry production. 'Phenomenal' blackberry is a parent of 'Young', which became a founding clone for breeding programs in Oregon, New Zealand, Australia, and others around the world.

Burbank (Fig. 6), the plant inventor, was very foresighted in predicting the development and importance of berry crops to U.S. agriculture. He had a strong vision for novelty and correctly predicted traits that would be of high economic value. His innovative breeding approach has led the way for the generations of berry breeders now crossing and releasing the newest improved berries for consumers to enjoy.

Literature Cited

- Burbank, L. 1914. Vols. 1, 2, 3, and 6. In: Whitson, J., R. John, and H.S. Williams (eds.). Luther Burbank: His methods and discoveries and their practical application. Luther Burbank Press, New York, NY.
- Fairchild, D. 1944. The world was my garden: Travels of a plant explorer. Charles Scribner's Sons, New York, NY. p. 132, 263–265.
- Hancock, J.F., C.E. Finn, A. Dale, J.J. Luby, P.W. Callow, and S. Serçe. 2010. Reconstruction of

the strawberry, $Fragaria \times ananassa$, using native genotypes of *F. virginiana* and *F. chiloensis*. HortScience 45:1006–1013.

- Heiser, C.B. 1987. The wonderberry. In: The fascinating world of the nightshades. 2 Oct. 2013. http://bulbnrose.x10.mx/Heredity/ HeiserWonderberry/HeiserWonderberry.html>.
- Howard, W.L. 1945. Luther Burbank's plant contributions. Bull. 691. University of California, Berkeley, CA.
- Hughes, H.G. and J. Janick. 1974. Production of tetrahaploids in the cultivated strawberry. HortScience 9:442–444.
- Jennings, D.L. 1988. Raspberries and blackberries: Their breeding, diseases and growth. Academic Press, London, UK.
- Lee, J., M. Dossett, and C.E. Finn. 2012. *Rubus* fruit phenolic research: The good, the bad, and the confusing. Food Chem. 130:785–796.
- McConahey, M. 2006. Burbank imported notorious blackberry. The Press Democrat, Santa Rosa, CA, 1 July 2006.
- Meng, R. and C.E. Finn. 2002. Determining ploidy level and nuclear DNA content in *Rubus* by flow cytometry. J. Amer. Soc. Hort. Sci. 127: 767–775.
- Smith, J.S. 2009. The garden of invention: Luther Burbank and the business of breeding plants. Penguin Press, New York, NY.
- Thompson, M.M. 1995. Chromosome numbers of *Rubus* cultivars at the National Clonal Germplasm Repository at Corvallis. HortScience 30:1453–1456.