

CANOVI Trial Brief: Heat-Tolerant Lettuce 2024



organic
SCIENCE CLUSTER 4

Executive summary: In 2024, CANOVI completed its second year of heat-tolerant lettuce variety trials on farms across Canada. Based on two years of national data ($n_{2023} = 53$, $n_{2024} = 37$), Magenta was once again the top-rated lettuce variety among growers, receiving the significantly high ratings for uniformity, vigor, marketability, flavour, bolt resistance, disease and pest resistance, and overall performance. While bolt resistance varied among different lettuce varieties, Magenta consistently showed strong resistance across low and high heat stress conditions. Although slightly less bolt-resistant than Magenta, varieties like Sangria, Bronze Beauty Arrowhead, and Biscia Rossa were also well-liked by growers.



Background: Leafy greens are a critical part of market garden systems, with participants consistently ranking leafy greens as a high priority crop in need of breeding improvement. While Magenta was the top performing and highest-rated variety in 2023, we wanted to repeat this trial in 2024 to confirm these results with more consideration to climate data.

Given the challenges of climate change and increasing summer temperatures, this trial aims to evaluate lettuce varieties sourced from open-pollinated (OP) and regionally grown seeds for their ability to perform in the middle of the summer, specifically their tolerance to premature bolting and their ability to maintain other desirable qualities.

Varieties: We chose 12 lettuce varieties across the three market classes that had the fewest options for heat-tolerant varieties: Batavian, Butterhead, and Oak Leaf. All varieties included were open-pollinated. Seeds of all varieties were grown in Canada, except Gentilina, which was grown in New York State within the same bioregion of southern Ontario and Quebec.

Results: Significant differences were identified among the 12 varieties across all agronomic traits except disease resistance, according to the statistical analysis. Magenta (Batavian market class) had the highest ratings for bolt resistance, uniformity, marketability, flavour, disease and pest resistance, and overall performance; however, it had a lower germination rate compared to other varieties (Table 1).

Growers most frequently selected Sangria (79%) as the Butterhead lettuce they would grow again, while Biscia Rossa and Bronze Beauty Arrowhead tied as the top choice (73%) for the Oak Leaf lettuce they would grow again.

Table 5. Average ratings for agronomic traits across varieties. All traits consider 2023 and 2024 agronomic data, except traits indicated with an asterisk (*) which only considers 2024 data. Darker coloured cells denote higher scores, with bolded numbers in red indicating the significantly highest score(s) among the variety.

Variety	Germination	Vigor	Bolt resistance	Uniformity	Marketability	Flavour	Scorch tolerance*	Disease and pest resistance*	Overall
Cardinale	3.62	3.98	3.79	3.68	3.66	3.62	4.21	4.00	3.40
Cougar	3.36	3.67	3.69	3.53	3.49	3.62	4.16	4.15	3.48
Gentilina	4.21	3.95	3.35	3.76	3.45	3.50	4.16	4.34	3.24
Magenta	3.49	3.95	4.40	4.05	4.08	4.02	4.43	4.41	3.92
Butter King	2.97	2.52	3.93	3.69	3.34	3.68	3.80	4.09	3.23
Buttercrunch Bibb	4.12	3.37	4.07	3.64	3.08	3.80	3.81	3.77	3.24
Grosse Blonde Paresseuse	4.10	3.96	3.81	3.87	3.32	3.08	3.70	3.89	3.18
Sangria	3.43	3.48	4.36	3.52	3.50	3.78	3.98	3.97	3.51
Biscia Rossa	3.08	3.79	3.56	3.95	3.63	3.76	4.20	4.25	3.56
Bronze Beauty Arrowhead	3.55	3.94	3.96	4.04	3.79	3.74	4.10	4.19	3.72
Red Oak Leaf Alberta	2.48	3.41	3.18	3.23	2.97	3.20	4.58	3.82	2.67
Red Oak Leaf Quebec	3.38	3.41	3.80	3.75	3.52	3.46	4.57	4.16	3.39

Takeaways and next steps: Magenta (from Saanich Organics) was the strongest performing variety across agronomic traits, especially bolt resistance. Varieties showed varying stability in germination, bolt resistance, and disease and pest resistance across different environments and seasons, which suggests that growers can adjust their lettuce selections based on their specific growing priorities, risk tolerance, and on-farm resources.

We encourage participants to [access SeedLinked to review](#) which lettuce varieties worked best in their specific regional climate and farming systems, with national data also available to act as a point of reference as needed.

More results can be found in full report below

CANOVI Full Report: Heat-Tolerant Lettuce 2024



Participant Locations

This study recruited 50 participants across Canada (Figure 1) with 36 completing the trial (72% completion). The University of British Columbia (UBC) Organic Farm and the Fertile Ground Farm (Ontario) acted as the mother sites of this trial, with each mother site planting three replicates of each variety as part of their trials.



Figure 1. The geographical spread of CANOVI lettuce participants across Canada in 2024.

Lettuce Varieties

Table 2 shows the full list of the lettuce varieties we selected for this study and their agronomic and breeding history. The full breeding history of each variety can be found in Table 8 of the Supplementary Materials at the end of this report.

Table 2. Overview of the agronomic and breeding history of the lettuce varieties included in this study.

Market Class	Cultivar	DTM	Breeder	Seed Grower
Batavian	Cardinale	60	French Heirloom brought back to popularity by Frank Morton of Wild Garden Seeds	Greta's Family Gardens, ON
	Cougar	55	Frank Morton of Wild Garden Seed, an OSSl variety	Hawthorn Farm Organic Seeds, ON
	Gentilina	48	Heirloom adapted by Fruition	Fruition Seeds, NY, USA
	Magenta	50	No records on the breeding history but well documented online to be heat tolerant	Saanich Organics, BC
Butterhead	Buttercrunch Bibb	50	George Raleigh at Cornell University and an All-America Selection winner in 1963	Jardin de l'Écoumène, QC
	Butter King	60	AAFC in Ottawa in 1965	Thyme Again, ON

	Grosse Blonde Paressuense	55	Vilmorin, a French seed company, in the 1800's	Jardin de l'Écoumène. QC
	Sangria	55	Bred from Mereville des Quatre Saisons by Vilmorin in 1989, the PVP expired in 2009	Salt Spring Seeds. BC
Oak Leaf	Bronze Beauty Arrowhead Oakleaf	46	Introduced by the Germania Seed & Plant Co. in the 1940s	Sage Garden. MB
	Biscia Rossa	50	Italian heirloom, dates back to at least 1977	La société des plantes. QC
	Red Oak Leaf Alberta	60	Heirloom, breeder unknown	Wild Rose Heritage Seed Company. AB
	Red Oak Leaf Quebec	45	Heirloom, breeder unknown, dates back to the 1770s	Ferme Tournesol. QC

Planting

We asked participants to plant a minimum of 10 plants at approximately 8-12" spacing. In all regions, we recommended seeding in mid-May to early June for transplanting just after the summer solstice (June 21). Using these planting dates, varieties with 50-60 days to maturity are ready for harvest in mid-August. Participants used their usual organic methods for soil fertility and weed management.

Evaluation

Participants evaluated varieties using the desktop or mobile [SeedLinked app](#) for germination, vigour, bolt resistance in hot weather, scorch tolerance, uniformity, marketability, flavour, disease and pest resistance, and overall performance on a scale of 1 (low) to 5 (high). Compared to the previous year, appearance was removed as a variable for observation, and scorch tolerance and disease and pest resistance were added. We provided a rubric that defined the rating scale for each trait. Further planting and evaluation details are available in the [2024 Lettuce Trial Protocol](#).

Analysis

Evaluation summaries were available on the SeedLinked website immediately after trial closure. In addition, CANOVI researchers compiled 2023 and 2024 lettuce data together for statistical analysis and presented results in this trial report.

Would you grow this again?

The summary results of growers' answers to the question of whether they would grow each lettuce variety again are shown in Figure 2. Some highlights were:

- **Magenta (87%), Sangria (79%), and Biscia Rossa/Bronze Beauty Arrowhead (73%) were the top variety in each of their market classes**, with Magenta being the most popular variety across all market classes. This mirrors results from 2023.
- The **lowest-rated variety across varieties and market classes was Red Oak Leaf Alberta (45%)** which aligns with results from the previous year.
- Compared to 2023, more 2024 growers said they would grow Buttercrunch Bibb (+17%) and Butter King (+10%), and less said they would grow Gentilina (-14%), Cardinale (-12%), and Cougar (-6%) again.

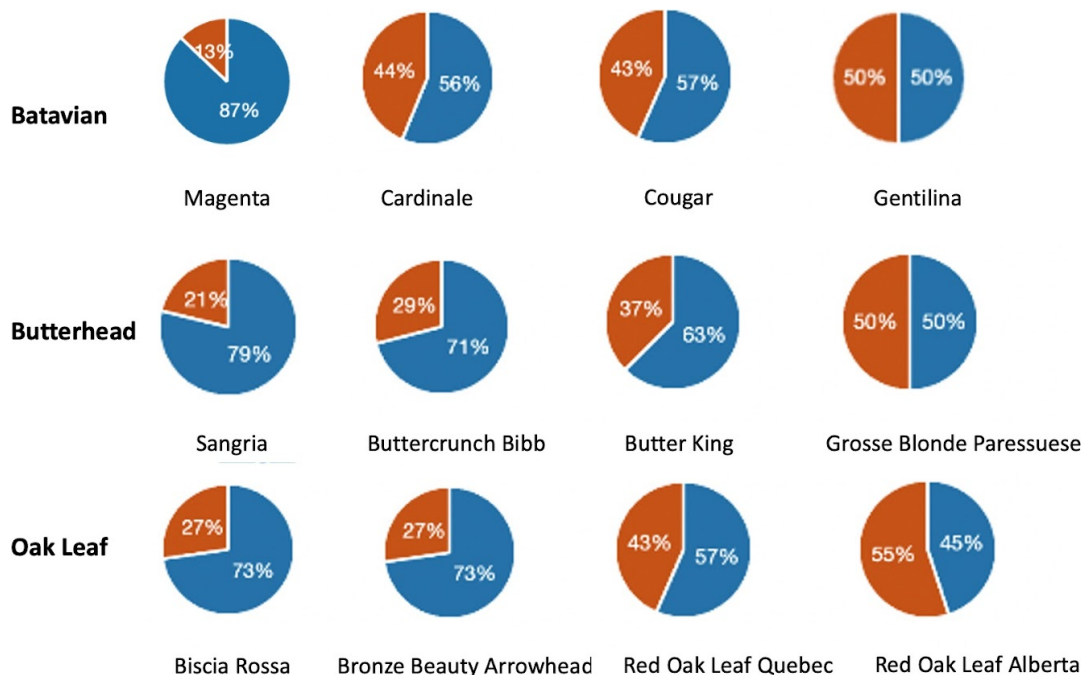


Figure 2. Percentage of participants who voted to grow a lettuce variety again, split up by marketclass. Red depicts the percentage of participants who would **not** grow a variety again, while blue depicts the percentage of participants who would grow a variety again.

Effect of variety, year, and hardiness zone on agronomic traits

All ANOVA (analysis of variance) statistical results are presented in Table 3, with each of the following variables of interest having the following effect:

- **Variety had a significant effect on all agronomic traits except disease and pest resistance.** That means significant variations of rating scores for those agronomic traits were found among the varieties.
- **Year had a significant effect on almost all agronomic traits, except bolt resistance and uniformity.** This significant effect was due to certain varieties having significantly different performances for select traits across years (Supp. Table 1). Specifically, Butter King's performance likely changed across years due to a change in seed source. The two Red Oak Leaf's performance change is likely due to their unstable genotypes. The bolt resistance and uniformity ratings of all varieties did not change over the two years.
- **Hardiness zone had a significant effect on all agronomic traits.** This significant effect is likely erroneous as different zones have variable sample sizes which skews the distribution and analysis of results.
- **Region (East vs. West) had a significant effect on germination and bolt resistance.** The average germination rate was higher in the East, while the average bolt resistance was higher in the West (Supp Table 2). These differences may be attributed to regional climate differences. Growers in the West generally report cooler and drier conditions, whereas those on the East Coast experience hotter and wetter conditions. Lettuce generally germinates better in warmer temperatures, which may explain the East's higher germination rate. In contrast, the West's cooler temperatures likely contribute to greater bolt resistance, as cooler conditions help delay

bolting. No significant difference was identified by region for other agronomic traits potentially because those traits were affected by a combination of other environmental factors (e.g., soil, irrigation, fertilizer) alongside the regional climate differences.

- **There were no significant interactions between variety*year and variety*hardiness zone for all agronomic traits, except for a significant effect for variety*year on germination.** The significant difference in germination between years could be explained by a change in CANOVI project coordination. In 2023, several growers reported delayed participation confirmation and seed deliveries, limiting the time and care growers could put into planting seeds. To address this, in 2024, project recruitment and on-boarding was done 2-4 weeks earlier so growers had ample time to familiarize themselves with research protocols and plant their seeds.

Table 3. Summary of ANOVA analyses on the effect of variety, year, and hardiness zone on agronomic performance across lettuce varieties. Scorch tolerance and disease and pest resistance averages, indicated with a “N/A”, only consider ratings from 2024. Region grouped participants by East (Ontario, Quebec, Nova Scotia, and Prince Edward Island) versus West (e.g., Alberta, British Columbia, and Saskatchewan) coast growers. Significant levels are denoted with the with the following symbols for p-values: <0.001 = *** (strongest effect), <0.01 = **, <0.05 = *, not significant = - (no effect).

Variable	Germination	Vigor	Bolt Resistance	Scorch Tolerance	Disease and Pest Resistance	Uniformity	Marketability	Flavour	Overall
Variety	***	***	***	*	-	**	***	***	**
Year	**	***	-	N/A	N/A	-	***	***	**
Hardiness zone	**	***	***	***	***	***	***	***	***
Region	*	-	***	-	-	-	-	-	-
Variety*Year	***	-	-	N/A	N/A	-	-	-	-
Variety*Hardiness zone	-	-	-	-	-	-	-	-	-

When comparing the performance of individual varieties to each other, there were significant differences between varieties across agronomic traits (Table 4). Some highlights were:

- **Magenta performed significantly higher than other varieties** for bolt resistance, uniformity, marketability, flavour, disease and pest resistance, and for overall performance.
- Although not as top performing as Magenta, **Bronze Beauty Arrowhead consistently had average ratings above those of most other varieties.**
- **Red Leaf Alberta, Red Leaf Quebec, and Butter King were consistently rated the lowest** three performing varieties for various agronomic traits. Interestingly however, the **Red Leaf Alberta and Quebec both had the highest scorch tolerance.**
- While **Biscia Rossa, Grosse Blonde Paresseuse, and Buttercrunch Bibb** were rated highly for select traits, they also rated the lowest for other traits, **showing a tradeoff in performance.**
- Despite these mixed agronomic results, growers most frequently selected **Sangria as the Butterhead lettuce and Biscia Rossa and Bronze Beauty Arrowhead as the Oak Leaf lettuces they would grow again.**

Table 4. Pairwise comparisons of average ratings of each agronomic trait across lettuce varieties in 2023 and 2024 (using Fisher’s LSD multiple pairwise comparisons). Scorch tolerance and disease and pest resistance averages only consider ratings in only 2024. Varieties are sorted by highest to lowest ratings for each agronomic trait. Varieties that have letters that differ from each other indicate significant differences.

Variety	Germination		Variety	Vigor		Variety	Bolt Resistance		Variety	Scorch Tolerance	
Gentilina	4.21	a	Cardinale	3.98	a	Magenta	4.40	a	Red Oak Leaf Alberta	4.58	a
Buttercrunch Bibb	4.12	a	Grosse Blonde Paresuuese	3.96	a	Sangria	4.36	ab	Red Oak Leaf Quebec	4.57	a
Grosse Blonde Paresuuese	4.10	a	Magenta	3.95	a	Buttercrunch Bibb	4.07	abc	Magenta	4.43	ab
Cardinale	3.62	b	Gentilina	3.95	a	Bronze Beauty Arrowhead	3.96	bcd	Cardinale	4.21	abc
Bronze Beauty Arrowhead	3.55	bc	Bronze Beauty Arrowhead	3.84	ab	Butter King	3.93	cd	Biscia Rossa	4.20	abc
Magenta	3.49	bc	Biscia Rossa	3.79	abc	Grosse Blonde Paresuuese	3.81	cd	Cougar	4.16	abc
Sangria	3.43	bc	Cougar	3.67	abcd	Red Oak Leaf Quebec	3.80	cd	Gentilina	4.16	abc
Red Oak Leaf Quebec	3.38	bcd	Sangria	3.48	bcd	Cardinale	3.79	cd	Bronze Beauty Arrowhead	4.10	abc
Cougar	3.36	bcd	Red Oak Leaf Quebec	3.41	bcd	Cougar	3.69	de	Sangria	3.98	bc
Biscia Rossa	3.08	cd	Butter King	3.41	cd	Biscia Rossa	3.56	def	Buttercrunch Bibb	3.81	c
Butter King	2.97	d	Buttercrunch Bibb	3.37	d	Gentilina	3.35	ef	Butter King	3.80	c
Red Oak Leaf Alberta	2.48	e	Red Oak Leaf Alberta	2.52	e	Red Oak Leaf Alberta	3.19	f	Grosse Blonde Paresuuese	3.70	c

Variety	Disease & Pest Resistance		Variety	Uniformity		Variety	Marketability		Variety	Flavor		Variety	Overall	
Magenta	4.41	a	Magenta	4.05	a	Magenta	4.08	a	Magenta	4.02	a	Magenta	3.92	a
Gentilina	4.34	a	Bronze Beauty Arrowhead	4.04	ab	Bronze Beauty Arrowhead	3.79	ab	Buttercrunch Bibb	3.89	ab	Bronze Beauty Arrowhead	3.72	ab
BisciaRossa	4.25	ab	Biscia Rossa	3.95	abc	Cardinale	3.66	ab	Sangria	3.78	abc	Biscia Rossa	3.56	abc
Bronze Beauty Arrowhead	4.19	ab	Grosse Blonde Paresuuese	3.87	abcd	Biscia Rossa	3.63	ab	Biscia Rossa	3.76	abc	Sangria	3.51	bc
Red Oak Leaf Quebec	4.16	ab	Gentilina	3.76	abcd	Red Oak Leaf Quebec	3.52	bc	Bronze Beauty Arrowhead	3.74	abc	Cougar	3.48	bc
Cougar	4.15	ab	Red Oak Leaf Quebec	3.75	abcd	Sangria	3.50	bc	Butter King	3.68	abc	Cardinale	3.40	bc
ButterKing	4.09	ab	Butter King	3.69	bcd	Cougar	3.49	bc	Cougar	3.62	bcd	Red Oak Leaf Quebec	3.39	bc
Cardinale	4.00	ab	Cardinale	3.68	bcd	Gentilina	3.45	bcd	Gentilina	3.50	cd	Buttercrunch Bibb	3.24	c
Sangria	3.97	ab	Buttercrunch Bibb	3.64	cd	Butter King	3.34	bcd	Cardinale	3.48	cd	Gentilina	3.24	c
Grosse Blonde Paresuuese	3.89	ab	Cougar	3.53	de	Grosse Blonde Paresuuese	3.32	bcd	Red Oak Leaf Quebec	3.46	cde	Butter King	3.23	c
Red Oak Leaf Alberta	3.82	ab	Sangria	3.52	de	Buttercrunch Bibb	3.08	cd	Red Oak Leaf Alberta	3.20	de	Grosse Blonde Paresuuese	3.18	c
Buttercrunch Bibb	3.77	b	Red Oak Leaf Alberta	3.23	e	Red Oak Leaf Alberta	2.97	d	Grosse Blonde Paresuuese	3.08	e	Red Oak Leaf Alberta	2.67	d

Variability of ratings for germination, disease and pest resistance, and bolt resistance

In the first year of the CANOVI heat-tolerance lettuce trials, growers reported variable experiences with seed germination and bolt resistance across climate conditions that potentially influenced the success and data accuracy of their variety trials. Growers also mentioned variable experiences with disease and pest resistance in 2023, which encouraged the trait to be added to the trial in 2024. To address the variability experienced by growers, rather than present data using averages, we presented these agronomic traits using violin plots to show how much they may potentially vary among growers across climate conditions.

The variability of germination ratings across varieties is presented in Figure 3 with data from 2023 and 2024. These plots show different agronomic stability between different varieties:

- Varieties with ratings concentrated near 4 and 5, like **Gentilina** and **Grosse Blond Paresseuse**, suggest that they have **stable germination rates across various growing conditions**. These varieties would be good options for growers who prioritize high germination rates, or those who need reliable germination because of sub-optimal growing conditions (e.g., have poor germination conditions, limited space).
- Varieties with a highly variable spread of ratings, like **Sangria** and **Biscia Rossa**, suggest that they have **unstable germination rates across different growing environments**. These varieties would work well for growers who like them, and are able to adapt their environmental conditions as needed to achieve their target germination rate.
- **Red Oak Leaf** from Alberta has **consistently low germination** as shown by most of its ratings concentrating near 1, suggesting that the low germination is a result of the genotype.

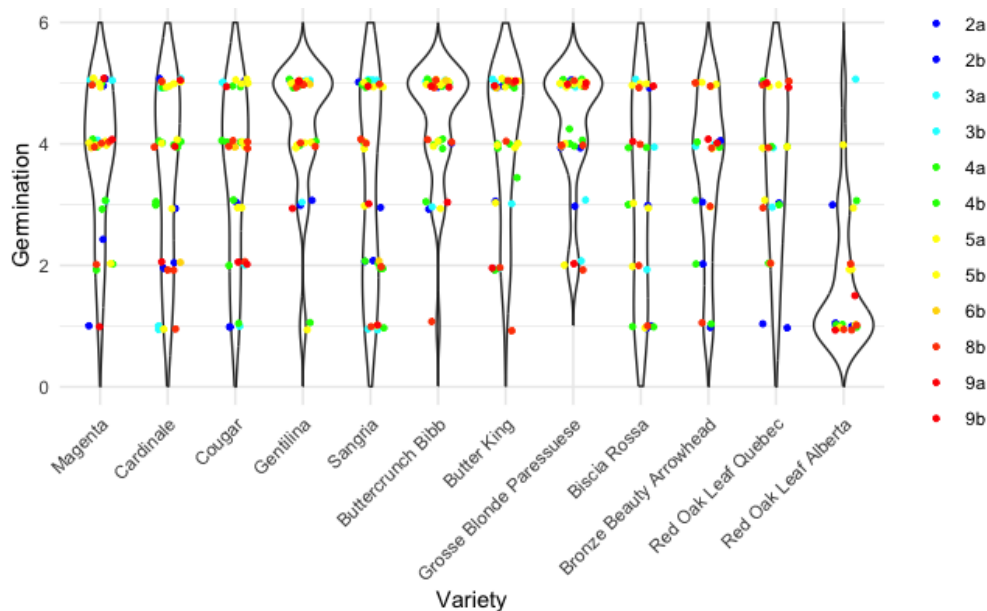


Figure 3. Violin plots show the variability of germination ratings in 2023 and 2024. Each dot represented a rating score from one grower and the color indicates the hardiness zone the grower was located in. Blue to red (colder regions to warmer regions).

The variability of bolt resistance across varieties is presented in Figure 4:

- Varieties like **Magenta** and **Sangria** have ratings that concentrate near 4 and 5, suggesting that these varieties **can withstand bolting in a wide range of growing conditions**. Growers who grow lettuce under conditions that can lead to premature bolting, like extreme heat and drought, may benefit from growing these varieties to achieve a harvest.
- **Varieties with variable ratings, like Cardinale or Red Oak Leaf Quebec, show unstable bolt resistance** performance across growing conditions.

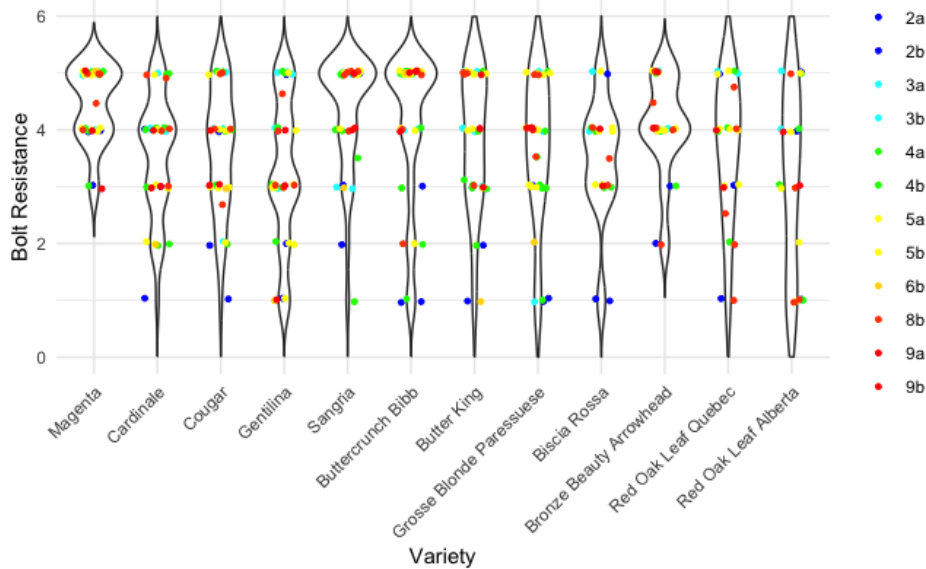


Figure 4. Violin plots showing the variability of bolt resistance ratings in 2023 and 2024. The coloured points represent different hardiness zones.

The variability of disease pest resistance across varieties is presented in Figure 5. Although no significant statistical difference was identified among varieties for disease pest resistance according to ANOVA results (Table 3), variations were found across environments (hardiness zone). Specifically:

- **Magenta, Cougar, and Red Oak Leaf Quebec tend to have the more stable disease and pest tolerance across environments.**
- **Comparatively, Sangria, Buttercrunch Bibb, and Red Oak leaf Alberta had more unstable disease and pest tolerance.** Growers who may have high disease and pest pressure, or those who grow in environments where disease spreads easily once present in the field, may want to avoid the varieties.

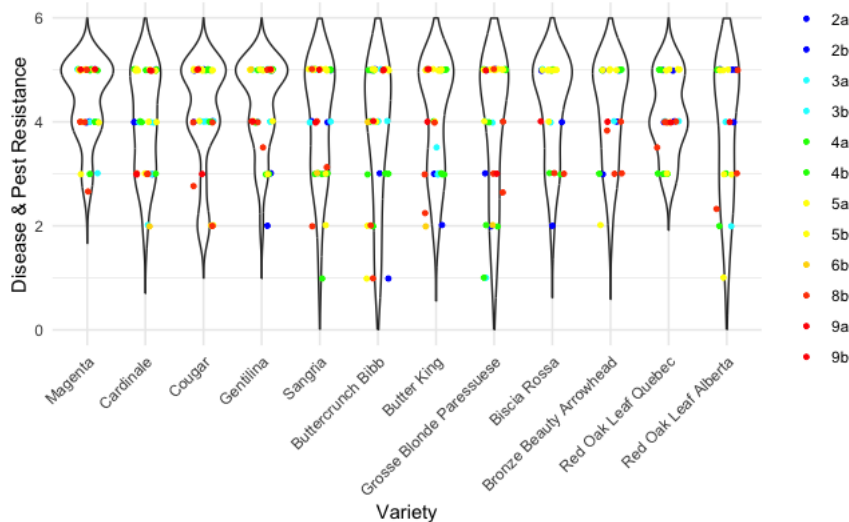


Figure 5. Violin plots showing the variability of disease and pest resistance ratings in 2023 and 2024. The coloured points represent different hardiness zones.

Qualitative observations on the trial from growers

CANOVI participants submitted various comments on individual lettuce varieties, climate conditions, and trial experience via SeedLinked, email communications, exit-survey results and conversations with regional coordinators. A summary of thoughts, observations, and experiences with specific varieties in relation to agronomic traits can be seen in Figure 6 and Table 5. Various growers on SeedLinked mentioned that participating in this trial helped them find new varieties that they plan on growing in the future. In the CANOVI exit survey, growers mentioned that participating in this trial was a lot of fun.

For varieties that growers liked but bolted or got heat-scorched before harvest, growers mentioned that they would harvest those heads early or harvest those varieties for cut lettuce in the future. A small number of growers mentioned experiencing challenges around saving viable seed for lettuce, especially among varieties with high bolt resistance.

Both in 2023 and 2024, a growing number of growers mentioned:

- Extreme weather conditions (e.g., heat, drought, excess rain) and variability (e.g., extreme heat one week then extreme cool the next) influenced their ability to successfully grow lettuce but also run fair and accurate variety trials. This is especially an issue for growers in areas where wildfires and/or floods are becoming more common with climate change.
- Grower, Connie Sabo, noted that climate change is affecting the regional phenology — the timing of seasonal patterns and their impact on the natural world. As a result, coordinating the right time to germinate and plant lettuce for observation in hot conditions, alongside timing and managing other on-farm priorities, was challenging this season.

This highlights the importance of working with diverse, open-pollinated seeds that can be adapted for climate-resilience.

Figure 6. Grower-submitted photos of nationwide lettuce trials from SeedLinked. Starting from the top left in clockwise order: Sebastian Chow's Biscia Rossa in Nova Scotia, Valerie Campeau's Magenta in Quebec, Karen Hutchinson's Buttercrunch Bibb in Ontario, Julie Wright's Red Oak Leaf Quebec in Alberta, and Heather Ramsay's Cougar (left) and Sangria (right) in British Columbia.



Table 5. Summary table of grower comments on SeedLinked related to disease and pest resistance, flavour, scorch and bolt tolerance, and overall performance. Overall, these observations only consider opinions from growers who did submit comments, and not growers who *did not* submit comments. Observations were included if at least 3 growers mentioned the same experience and/or opinion, although some unique individual observations were included and explicitly labeled as such. Blank cells indicate instances where no or too few comments were submitted.

Variety	Disease and Pest Resistance	Flavour	Scorch/Bolt Tolerance	Overall
Cardinale	Pests liked to chew/mark the leaves	Mixed reports of sweet and bitter + tender and tough leaves across growers; crunchy texture	Bolted before or at maturity	Short harvest window
Cougar	Good disease resistance but reports of animals chewing on leaves	Majority report tough and bitter heads; firm crunchy texture but not tough	Bolted at or after maturity	
Gentilina	A grower who had grasshopper issues for their entire trial mentioned that the grasshoppers did not eat this until the end	Mixed sweet/bitter flavour; soft-crunchy texture	Mixed reports of bolting before, at, and post maturity	Mixed reports on vigor
Magenta	Great disease resistance	Delicious	Bolted at or after maturity	Beautiful; bolt resistant
Buttercrunch Bibb	Prone to humidity-related disease	Crunchy, sweet, juicy	Poor scorch tolerance overall; bolted at or after maturity	Slow to grow; delicious
Butter King	Held up well for some growers, while other growers mentioned pest issues (grasshopper, slugs, aphids, thrips)	Mixed reports of sweet/juicy and bitter/dry across growers; healthy fully formed heads had better flavour than stunted heads	Most heads bolted before maturity	
Grosse Blonde Paresseuse	Mixed reports of disease resistance	Mixed sweet/bitter flavour	Bolted at maturity	Suggest earlier harvest to avoid bolted heads
Sangria	Mixed reports of disease resistance	Delicious; mixed sweet/bitter flavour; crunchy	Bolted at or after maturity	Beautiful; holds up well in the field and post-harvest
Bronze Beauty Arrowhead	Held up well		Mixed reports of bolting before, at, and post maturity; starts bolting a week before or at maturity	Beautiful
Biscia Rossa		Delicious		
Red Oak Leaf Alberta		Bitter	Mixed reports of bolting before, at, and post maturity	Bad germination
Red Oak Leaf Quebec				A grower reported this that was early in Quebec; good flavour

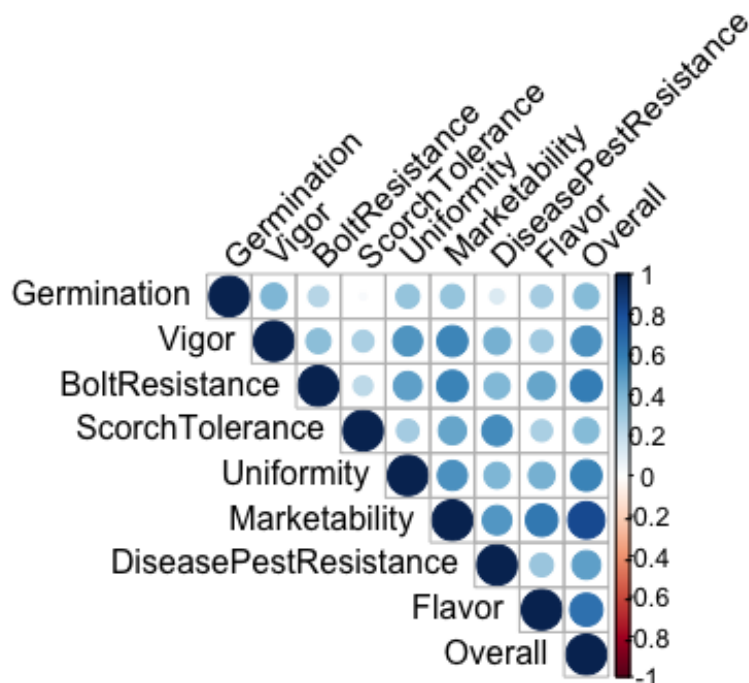
Supplemental Materials

Supp. Table 1. Average ratings of agronomic traits across lettuce varieties in each market class in 2023 and 2024. Significant levels of impact of “variety” are denoted with the with the following symbols for p-values: <0.001 = *** (strongest effect), <0.01 = **, <0.05 = *, not significant = - (no effect). Darker green color indicates higher scores, while bolded numbers in red indicate the significant changes from 2023 to 2024 (p<0.01).

Market Class	Variety	Germination		Vigor		Bolt resistance		Uniformity		Marketability		Flavour		Overall	
		***		***		***		**		***		***		**	
		2023	2024	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024	2023	2024
Batavian	Cardinale	3.68	3.56	3.95	4.01	4.00	3.54	3.86	3.47	3.58	3.73	3.44	3.53	3.51	3.26
	Cougar	3.20	3.54	3.56	3.81	3.72	3.65	3.43	3.65	3.35	3.65	3.45	3.85	3.55	3.41
	Gentilina	4.15	4.29	3.74	4.20	3.39	3.29	3.65	3.90	3.16	3.77	3.32	3.71	3.06	3.45
	Magenta	3.24	3.79	3.94	3.97	4.37	4.44	3.88	4.25	3.84	4.34	3.95	4.11	3.75	4.13
Butter-head	Butter King	2.06	4.04	3.03	3.85	4.06	3.78	3.42	3.94	3.18	3.49	3.50	3.90	3.00	3.50
	Buttercrunch Bibb	3.92	4.36	3.06	3.76	4.11	4.03	3.41	3.91	2.72	3.52	3.79	4.01	2.88	3.71
	Grosse Blonde Paressuese	3.95	4.28	4.00	3.92	3.95	3.64	3.97	3.75	3.29	3.36	2.97	3.23	3.20	3.16
	Sangria	3.52	3.31	3.35	3.64	4.40	4.32	3.53	3.51	3.23	3.81	3.72	3.86	3.44	3.60
Oak Leaf	Biscia Rossa	3.00	3.16	3.71	3.88	3.61	3.50	3.91	4.00	3.62	3.64	3.75	3.76	3.46	3.68
	Bronze Beauty Arrowhead	3.56	3.54	3.75	3.93	3.90	4.02	3.95	4.14	3.61	3.96	3.43	4.12	3.64	3.81
	Red Oak Leaf Alberta	3.18	1.72	2.77	2.25	3.18	3.20	3.40	3.04	2.86	3.08	2.87	3.59	2.62	2.73
	Red Oak Leaf Quebec	3.15	3.63	3.04	3.74	3.96	3.64	3.51	3.96	3.14	3.82	2.90	4.05	3.06	3.67

Supp. Table 2. Average ratings for agronomic traits by East and West in the two-year trials.

	Germination	Vigor	BoltResistance	ScorchTolerance	Disease Resistance	Uniformity	Marketability	Flavor	Overall
	*	—	***	-	-	-	-	-	-
East	3.66	3.72	3.72	4.09	4.11	3.70	3.53	3.66	3.39
West	3.41	3.57	4.00	4.14	4.06	3.75	3.44	3.56	3.38



Supp. Figure 1. Correlation matrix between agronomic traits of 2024 nationwide lettuce trial data. Darker colors indicate a higher correlation between any two traits and the associated values (known as r-values) indicate the strength and directionality of the correlation. Higher values indicate that two traits change strongly together, while lower values indicate that two traits change weakly or not at all with each other. The sign of the r-value indicates whether the correlative changes are positive or negative.

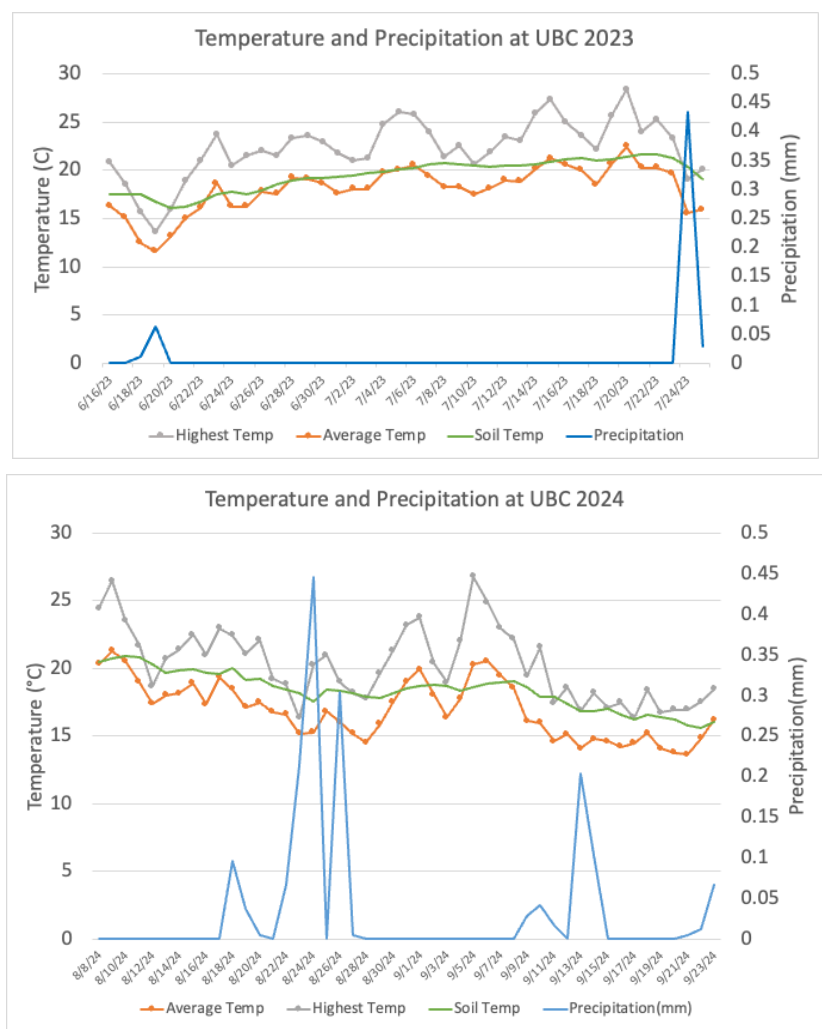
The strongest correlation was found between The results indicated marketability and overall performance. Better vigor was correlated with better uniformity, marketability and overall performance. Bolt resistance was also found to have positive correlations with uniformity, marketability and overall performance scores.

UBC Organic Farm Mother Site

In the 2024 UBC trial, the first round of lettuce seedling production led to crop failure due to stressful drought. The trial was re-sown at a different greenhouse at UBC on July 4th with success; however, there were not enough Buttercrunch Bibb and Biscia Rossa seeds to do a second sewing thus they were not able to be included in the trial. Lettuce seedlings were transplanted on August 8th at three replicate plots per variety. Two assessments were conducted on September 16th and September 23rd.

The temperature and precipitation at the UBC mother site are shown in Supp. Figure 1. In 2023, the trial was conducted from June 16 (transplanting date) to July 24 (2nd assessment date). In 2024, the trial was delayed due to technical issues and was conducted from August 8 (transplanting date) to September 23 (2nd assessment date). In 2024, the highest temperature ranged from 16-27°C with an average temperature of 14 - 21 °C. There was one significant precipitation between August 18-27 with

a total of 1.17mm of rain, and a second significant precipitation between September 9-14 with a total of 0.4mm of rain. In general, the climate for the 2023 trial was hotter than in 2024.



Supp. Figure 2. Highest daily temperature (°C), average daily temperature, soil temperature (°C), and precipitation (mm) at UBC. Data obtained from UBC Totem Field Climate Station (Biometeorology and Soil Physics Group).

ANOVA analysis was conducted to test the impact of variety, year (if applicable), and their interaction on the agronomic traits. The results indicated that **variations were identified among varieties for all traits except bolt resistance** (Supp. Table 1). Variations were also found in uniformity, marketability, flavor, and overall performance from 2023 to 2024.

Supp. Table 3. The ANOVA results of 2023 and 2024 UBC trial data. Germination and vigor consider 2023 ratings only. Scorch tolerance and disease and pest resistance were evaluated in 2024 only. Significant levels are denoted with the following symbols for p-values: <0.001 = *** (strongest effect), <0.01 = **, <0.05 = *, not significant = - (no effect).

	Germination	Vigor	Bolt Resistance	Scorch Tolerance	Disease&Pest Resistance	Uniformity	Marketability	Flavor	Overall
Variety	***	***	-	***	***	***	***	***	***
Year	N/A	N/A	-	N/A	N/A	***	***	***	***
Variety*									
Year	N/A	N/A	-	N/A	N/A	-	**	-	-

The average scores of agronomic traits across the 12 lettuce varieties are shown in Supp. Table 4 below. For most varieties, **the 2024 ratings were significantly lower than the 2023 ratings** across the tested traits. The delayed trial date resulted in a less favorable climate environment for the lettuce than the previous year.

Supp. Table 4. Average scores of agronomic traits across lettuce varieties in 2023 and 2024 trials at UBC. Ratings were the average of the three replicates and the two assessments. Germination and vigor data for 2024 were failed to collect. Scorch tolerance and disease and pest resistance were evaluated in 2024 only.

Market Class	Variety	Germi nation	Vigour	Bolt Resistance		Scorch Tolerance	Disease & Pest Resistance		Uniformity		Marketability		Flavour		Overall	
		2023	2023	2023	2024	2024	2024	2024	2023	2024	2023	2024	2023	2024	2023	2024
Batavia n	Cardinale	5	5.0	5.0	4.9	3.8	3.0	4.3	2.6	5.0	3.3	3.8	2.9	4.5	3.0	
	Cougar	3	4.5	5.0	5.0	4.0	2.8	3.8	2.8	4.8	3.5	3.8	3.0	4.3	3.0	
	Gentilina	5	5.0	5.0	4.6	3.0	3.5	4.9	3.4	4.3	3.3	3.8	3.4	4.0	3.3	
	Magenta	3	4.7	5.0	5.0	3.3	2.7	4.2	3.2	4.9	3.7	4.7	3.3	4.2	3.2	
Butterh ead	Buttercrunch Bibb*	4	2.6	5.0				3.1		1.5		3.5		2.0		
	Butter King	1	4.7	5.0	5.0	2.3	2.3	3.5	3.1	4.6	2.8	4.2	2.9	3.8	2.4	
	Grosse Blonde Paressuese	5	4.6	4.8	5.0		2.6	3.5	2.7	2.3	2.4	3.2	2.1	2.8	2.1	
	Sangaria	5	3.8	5.0	5.0	3.5	3.1	4.1	2.9	4.0	3.0	4.4	3.3	3.5	3.0	
Oak Leaf	Bisica Rossa	1	5.0	5.0				4.8		4.8		4.8		4.5		
	Bronze Beauty	4	5.0	5.0	5.0	4.0	3.8	4.8	3.2	4.3	4.0	3.8	3.8	3.8	4.0	
	Red Oak Leaf Alberta	1	3.8	5.0	5.0	3.0	2.3	3.7	2.8	3.7	2.7	3.8	2.7	3.2	2.0	
	Red Oak Leaf Quebec	2	3.8	5.0	4.8	4.0	3.5	3.9	3.1	4.5	3.4	4.8	3.5	4.2	3.5	

*Buttercrunch Bibb and Biscia Rossa data failed to be collected in 2024 due to a lack of seeds.

Even though some varieties were identified to have bolting issues according to the nationwide results, **none of the varieties had bolting issues at UBC farm in both 2023 and 2024**. Magenta was not the best variety at UBC which is different from the nationwide result. Instead, Bronze Beauty Arrowhead had the highest rating for overall performance, while it ranked in the second place in nationwide results. Varieties in the butterhead market class had lower ratings at UBC farm compared to nationwide results. In the oak leaf market class, red oak leaf alberta had lowest ratings which aligns with the nationwide results.

Fertile Ground Farm (Ontario) Mother Site

Fertile Ground Farm is located in South Ontario and acts as the other mother site on the East Coast, compared to the mother site on the West Coast (UBC). In this trial, varieties were sown on Jun.7 and transplanted in early July. Three replicated plots were planted for each variety. Germination, vigor, uniformity, disease pest resistance, and overall performance of all varieties were assessed by the grower.

ANOVA analysis was conducted to test the impact of variety on the agronomic traits. The results indicated that **variations were identified among varieties for all traits except vigor** (Supp. Table 5).

Supp. Table 5. The ANOVA results of the 2024 trial at Fertile Ground Farm.

	Germination	Vigor	Uniformity	Disease&Pest Resistance	Overall
Variety	***	-	***	**	***

Supp. Table 6. Average scores of agronomic traits across lettuce varieties in 2024 trial at Fertile Ground Farm.

Market Class	Variety	Germination	Vigor	Uniformity	DiseasePestResistance	Overall
Batavian	Cardinale	3.00	4.50	4.33	4.00	4.67
	Cougar	4.33	4.00	3.00	2.67	2.67
	Gentilina	5.00	4.00	3.67	3.00	3.33
	Magenta	4.33	5.00	5.00	5.00	5.00
Butterhead	Buttercrunch Bibb	5.00	3.50	3.00	3.00	3.33
	Butter King	5.00	4.00	3.00	3.00	3.00
	Grosse Blonde Paressuese	5.00	3.00	3.67	2.67	3.67
	Sangria	4.00	3.00	3.00	3.00	3.00

Oak Leaf	Biscia Rossa	3.33	4.50	4.33	4.33	4.33
	Bronze Beauty Arrowhead	2.00	4.50	5.00	4.33	5.00
	Oak Leaf Alberta	1.00	1.00	3.00	3.00	2.00
	Oak Leaf Quebec	5.00	4.00	3.00	3.67	3.67

Bolt resistance, scorch resistance, marketability, and flavor scores were not reported by the grower.

Magenta and Bronze Beauty arrowhead both had an overall performance score of 5 at this location, as they also ranked as first and second for the overall performance in the nationwide results. Grosse Blonde Paresseuse ranked on top in the butterhead market class at this location, which is different from the nationwide results that Sangria ranked on top. In the oak leaf market class, red oak leaf alberta had lowest ratings which aligns with the both UBC mother site and nationwide results.

Breeding histories of lettuce varieties

Table 9. Breeding histories of lettuce varieties included in this lettuce trial.

Variety	Breeding history
Butter King 	The Canadian Journal of Plant Science reported on the development of Butter King in 1967 (Vol. 47). It was bred at the Central Experimental Farm Research Station in Ottawa from an Israeli variety, Rinat Hakfar. Three of the most vigorous plants that were also the slowest to bolt and to develop tipburn comprised the initial selection. Rigid selection in seed plots was continued for 4 years to eliminate variability in several traits and produce this remarkably uniform strain. Butter King was awarded the Bronze Medal in the 1964 All-American Selections open trial-ground competition and was introduced commercially in 1965 in the US and Canada. References: • cucurbitbreeding.wordpress.ncsu.edu/2016/06/02/lettuce-a-l/ • cdnsiencepub.com/doi/pdf/10.4141/cjps67-081
Grosse Blonde Paresseuse 	Grosse Blonde Paresseuse translates to The Big Lazy Blonde and is also known as Cuirassière blonde de Nonpareille, Very Large Yellow Paresseuse, and Large White Stone Summer Lettuce. The variety was introduced by Vilmorin in France and dates back to at least 1854. It was noted in variety trials in the late 1800's as well adapted to summer culture. References: • plus.lapresse.ca/screens/f2ebf65b-7edc-4ff5-8de7-89bbe2d5f0%7C_0.html • horticultural-history.blogspot.com/2017/04/1885-e-l-sturtevant-lettuce-lettuce-and.html • tile.loc.gov/storage-services/public/gdcmassbookdig/descriptiondesp100vilm/descriptiondespl00vilm.pdf

Sangria



Sangria was bred by Vilmorin from the variety Merveille des quatre Saison in 1987. According to the USDA PVP certificate issued to Vilmorin, the variety was bred to create a Butterhead type that was not only resistant to Bremia and LMV (Lettuce Mosaic Virus) but also much more resistant to heat than the parent variety.

Sangria was released in the market in 1989 and the PVP expired in 2010.

References:

- apps.ams.usda.gov/cms/adobeimages/008900182.pdf
- www.ams.usda.gov/sites/default/files/media/2016%20PVPO%20App%20lication%20Status%20Report.pdf

Buttercrunch Bibb



Buttercrunch Bibb was developed by George Raleigh at Cornell University in the late 1950's to early 1960s. It was a 1963 All-America Selection *Edible Vegetable* winner, which mentioned that this variety holds well under stress and has good bolt resistance. It was the first Cornell-bred crop variety to win this award.

Buttercrunch Bibb was listed as a recommended home vegetable garden variety in Michigan State University Extension Bulletin E-760a in 1983, and in University of Minnesota Agricultural Extension Service Fact Sheet #104 in 1981.

References:

- cucurbitbreeding.wordpress.ncsu.edu/2016/06/02/lettuce-a-l/
- all-americaselections.org/product/lettuce-buttercrunch/
- conservancy.umn.edu/bitstream/handle/11299/207251/MN2000_FS_Y_104.pdf?sequence=1&isAllowed=y
- archive.lib.msu.edu/DMC/Ag.%20Ext.%202007-Chelsie/PDF/e760ar-ev5.pdf
- www.seedquest.com/News/releases/usa/Universities/n3904.htm

Magenta



We found no records on the breeding history of Magenta though it is well documented online to be heat tolerant.

Bronze Beauty Oak Leaf 	Bronze Beauty, also known as Bronze Beauty Arrowhead, was introduced by Germania Seed and Plant Co. It was an AAS bronze winner in 1947. It is not registered in the UPOV or <i>EU Common Catalogue Information System</i> databases for seed. References: • https://shop.seedsavers.org/bronze-arrowhead-lettuce • https://all-americanselections.org/product/lettuce-bronze-beauty/
Feuille de chene rouge and Red Oak Leaf 	The rather generic variety Red Oak Leaf does not seem to have much available breeding history information. Multiple websites, including the US National Gardening Association, date the oak leaf lettuce variety back to Vilmorin in 1771. References: • garden.org/plants/view/92473/Lettuce-Lactuca-sativa-Oakleaf/
Biscia Rossa 	Biscia Rossa translates to Red Snake. It is referenced in many places as an Italian heirloom variety and listed in the EU Seeds database where it is registered by Assosementi. It dates back to at least 1977. It is also known as, Rossa a foglia riccia da taglio (Red curly leaf for cutting). References: • www.sementi.it/documenti/registri/ITA-ortive/ortive-03.pdf • ec.europa.eu/food/plant-variety-portal/index.xhtml
Cardinale 	Cardinale is noted in many places online as a French heirloom but has no details about its breeding or development history. It is listed in the EU Seed Database as registered (but surrendered) to Gautier Seeds in France. It is not listed in the UPOV database. Cardinale is not listed by Seed Savers Exchange. Seeds of Diversity Canada lists it but with no historical info. This variety is a non-heading variety, in contrast to the variety Head Cardinale, which was bred from Cardinale by Frank Morton and is carried by many North American small seed companies.

	References • https://osseeds.org/ossi_variety/head_cardinal/ • https://ec.europa.eu/food/plant-variety-portal/index.xhtmll
Gentilina 	This variety of Gentilina came from Fruition Seeds who have been growing it for over 10 years. The variety is described in several places as originating from Northern Italy. Franchi Seeds in Italy refers to Gentilina as a lettuce <i>type</i> (lettuce with large loose leaf with frilly leaves), and sells it under the variety name Grand Rapids, a popular looseleaf. As a result, Gentilina and Grand Rapids may have the same or similar histories. References: • franchisementi.it/?s=gentilina&post_type=product&type_aws=true • www.fruitionseeds.com/shop/vegetables/lettuce/organic-gentilina-lettuce/ • www.theheirloomseedstore.com/product/lettuce-lattuga-gentilina • ruthreichl.com/wp-content/uploads/2013/12/index1.php • issuu.com/italseeds/docs/email_franchi_seeds_of_italy_catalogue_2024
Cougar Batavian 	The variety Cougar Batavian is an OSSI-pledged variety selected by Frank Morton. Its origin is described as an errant seedling in a flat of unrelated lettuce. It appears to be one of our Batavian types crossed to 'Brown Goldring.' This is distinct from the variety Cougar bred by Jodi Grossen of Seminis-Genecorp, described as a Romaine with dark green colored leaves, leaf surface moderately blistered, tall, wide long leaves. References • cucurbitbreeding.wordpress.ncsu.edu/2016/06/02/lettuce-a-l/ • cucurbitbreeding.wordpress.ncsu.edu/files/2016/04/vegetable-cultivar-descriptions-for-north-america-list-26-2002.pdf • osseeds.org/ossi_variety/cougar-batavian-2/ • hawthornfarm.ca/products/copy-of-cougar?_pos=1&_sid=aa85bfe5d&_ss=r