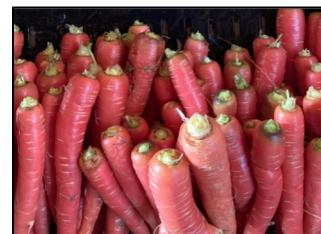


Trial Report: Red Nantes Carrots 2022

Goal: This trial's original goal was to test the CANOVI red Nantes carrot population alongside commercial hybrid (F1) and open-pollinated (OP) cultivars to gauge its readiness for commercialization. However, the CANOVI red population had almost no germination – due to a thrips issue in our greenhouse seed production – so our adjusted goal became to compare commercial red carrot cultivars, with emphasis on identifying OP cultivars that compete well with hybrids.



Background: The CANOVI Red Nantes carrot breeding project began in the summer of 2019, when CANOVI red carrot trials revealed a need for a **bolt-resistant, good tasting, smooth, blunt-tipped red carrot** for reliable root and seed production in Canada. Bauta Initiative BC partner FarmFolk CityFolk led this project, sourcing parents from trial fields of the Carrot Improvement for Organic Agriculture (CIOA) project and carrying out two rounds of selection since then. CANOVI on-farm and hub site carrot trials have been conducted in 2018-2020, and in 2022.

Varieties: In addition to CANOVI Red, participants trialed five commercially available carrot varieties: two F1 and three OP. Red Sun F1, Rubypak F1, Carnelian, and R6220 are “true” red varieties in that their red colour comes from lycopene, a carotenoid pigment. Dragon is an orange carrot with purple (anthocyanin) exterior, so it may fill a market niche for non-orange carrots for some growers, but it is not directly comparable to the other red carrot varieties.

Participants: 30, of whom 10 collected supplementary data.

Variety	OP / F1	Days to Maturity	Breeder	Seed Source
CANOVI Red	OP		CANOVI	CANOVI / UBC
Dragon	OP	70	John Navazio	Johnny's Selected Seeds
Red Sun F1	F1	70	Bejo Seeds	Johnny's Selected Seeds
Rubypak F1	F1	72	Bejo Seeds	Johnny's Selected Seeds
Carnelian	OP		Organic Seed Alliance	Organic Seed Alliance
R6220	OP		Organic Seed Alliance	Organic Seed Alliance

Planting: Participants planted 12 linear feet per variety at approximately 1” spacing after thinning, using single or multiple rows per bed. Seeds were sown in June or early July for harvest in September-October. Participants used their usual organic methods for soil fertility and weed management.

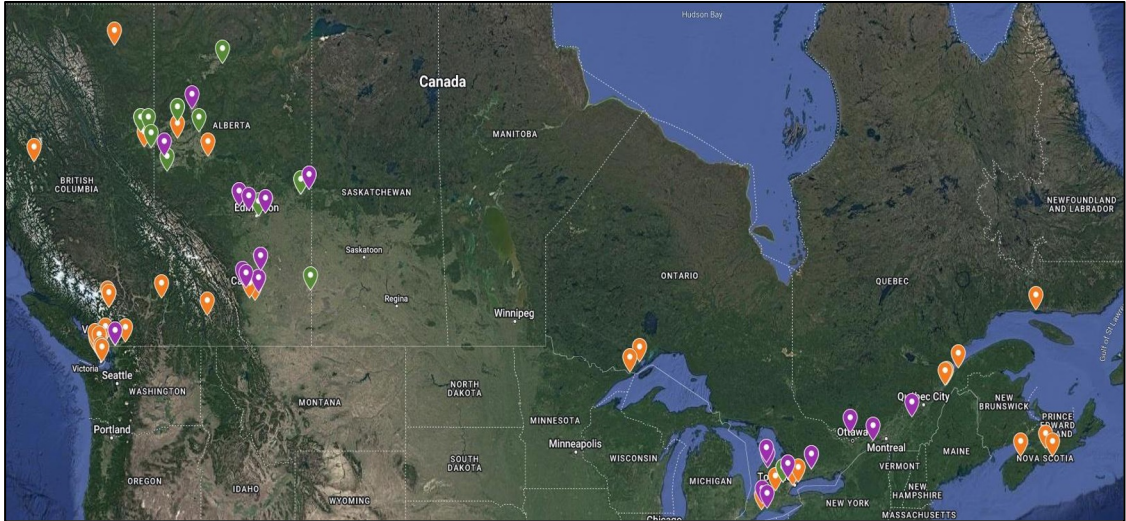
Evaluation: Participants evaluated varieties using the desktop or mobile [SeedLinked](#) app. Germination, early vigour, canopy cover, uniformity, yield, marketability, appearance, bolt resistance, and flavour were rated on a scale of 1 (low) to 5 (high). A rubric was provided that defined the rating scale for each trait. A subset of participants collected quantitative yield data and submitted comments on marketability and relative maturity.

Results and analysis: Interactive plots were available on the SeedLinked website immediately after trial closure. In addition, CANOVI researchers performed statistical analysis and presented results in a webinar and in this trial report.



Please view the 2022 CANOVI Carrot Trial Protocol for full instructions and the evaluation rubric.

Participant Locations



Orange Flag = Carrot Trial Participant

- **When we divided participants by East-West region, we found more regional differences in trait ratings than by dividing participants by hardness zones.**
 - East = 13 participants in NS, QC and ON
 - West = 17 participants in BC and AB

Mean Ratings by Region

	Appearance	Bolt Resistance **	Canopy Cover	Flavor	Germination *	Marketability ^	Uniformity	Vigor	Yield
East	3.3	4.8	2.9	3.1	2.9	2.9	3.2	3.2	2.8
West	3.6	4.1	3.2	3.1	3.3	3.2	3.3	3.3	3.2

Means and significant variation by region in 2-way fixed effects ANOVA with East/West as environmental variable
Green = High rating; Yellow = Mid-range rating; Red = Low rating

- **Germination*** and **marketability^** were rated higher on Western farms than Eastern farms.
- **Bolt resistance**** was significantly better for Eastern participants, likely due to their lower average latitude.
- There were **no cases of genotype x environment interaction (GxE)** in which one variety did significantly worse or better in one region than the other.

	P (<F)	Strength of evidence
^	<0.10	Weak
*	<0.05	Moderate
**	<0.01	Strong
***	<0.001	Very strong

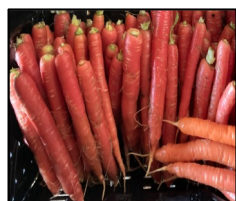
Mean Ratings by Variety

	Appearance *	Bolt Resistance	Canopy Cover ***	Flavor	Germination ***	Marketability ^	Uniformity *	Vigor ***	Yield ***
Dragon	3.8	4.6	3.9	3.4	4.0	3.5	3.4	4.3	3.8
Rubypak	3.5	4.5	3.2	3.1	3.2	3.1	3.1	3.4	3.3
Red Sun	3.8	4.7	3.3	3.1	3.8	3.1	3.5	3.4	3.2
Carnelian	3.4	4.2	2.9	3.2	2.9	3.0	3.3	2.9	2.7
R6220	2.9	4.0	2.0	2.9	1.7	2.5	3.0	2.1	2.0

Means and significant variation by variety in 2-way fixed effects ANOVA with East/West as environmental variable
Green = High rating; Yellow = Mid-range rating; Red = Low rating

- The **productivity traits** of germination***, canopy cover***, vigour***, and yield*** varied strongly among varieties. **Variety rank varies among these traits**, but the table above is sorted by yield.
- For the **quality traits** of appearance* and marketability^, R6220 was rated significantly lower than one or two commercial varieties. However, no significant differences existed between commercial varieties Dragon, Red Sun F1, Rubypak F1, or Carnelian.
- No significant differences in uniformity or flavour were found among varieties.

Quantitative Yield



Red Sun F1

Variety	Percent Marketable Yield	Marketable Yield (Lbs)	Total Yield (Lbs)
Dragon	70%	7.4	10.3
Red Sun	61%	4.3	6.4
Rubypak	64%	3.9	6.0
Carnelian	60%	3.9	5.7
R6220	70%	2.7	4.3
CANOVI Red	86%	2.2	2.7
Mean with CANOVI Red	69%	4.1	5.9
Mean without CANOVI Red	65%	4.4	6.5



Carnelian

Yield from 12 linear feet, as measured by 10 CANOVI trial participants

- Percent marketable yield was **between 60-70%** for all varieties, excluding CANOVI Red.
- Note that **OP Carnelian showed yield quite similar to hybrids Red Sun F1 and Rubypak F1**.

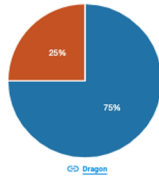
	P (<F)	Strength of evidence
^	<0.10	Weak
*	<0.05	Moderate
**	<0.01	Strong
***	<0.001	Very strong

Images: Delisa Lewis, BC

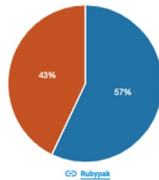
Varieties by Overall Preference



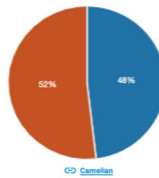
Dragon



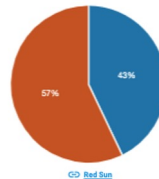
Rubypak F1



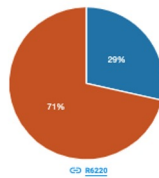
Carnelian



Red Sun F1



R6220



Blue = Would grow again
Red = Would not grow again
 Varieties are ordered by percent of participants who would grow the variety again

Results by Variety

- **Dragon** was highly vigorous and productive in both regions, but flavour did vary among farms. On Eastern farms, Dragon was rated highest for all traits except bolt resistance and appearance. On Western farms, Dragon was rated highest for all traits except bolt resistance, germination and uniformity.
- **Dragon, Red Sun F1, and Rubypak F1** performed quite similarly. In the West, Red Sun F1 did not differ significantly than Dragon or Rubypak F1 for any trait. In the East, Red Sun F1 showed lower vigour than Dragon, but no other trait ratings were significantly different between the three varieties.
- Among the 'true' red carrot varieties, **Red Sun F1, Rubypak F1, and Carnelian** were rated very similarly. They were not rated as significantly different from one another for any traits.
- Participants noted slightly **darker red colour** in Rubypak F1 than Red Sun F1, but some mentioned **rough appearance** for Rubypak F1. Red Sun F1 has occasional orange off-types but some participant comments praised the **light red colour**.
- **Carnelian**, an OP variety bred for organic conditions through the CIOA project, showed **similar productivity** to hybrid red carrot varieties and could be a good OP red carrot option. A few Northern growers mentioned **issues with bolting**, but several also commented on Carnelian's **pleasant flavour**. Carnelian will be newly available in 2023 through High Mowing Organic Seeds.
- **R6220**, still under development in the CIOA project, was rated **significantly lower for productivity traits** than Dragon and Red Sun F1 in both regions. However, several participants commented that it had unique and delicious flavour.

This research is part of [Organic Science Cluster 3](#), led by the [Organic Federation of Canada](#) in collaboration with the [Organic Agriculture Centre of Canada at Dalhousie University](#), supported by Agriculture and Agri-Food Canada's [Canadian Agricultural Partnership- AgriScience Program](#), [The Bauta Family Initiative on Canadian Seed Security](#), and the [Centre for Sustainable Food Systems at the UBC Farm](#).

Trial data analysis and report by Dr. Solveig Hanson, CSFS at UBC Farm. For more information, please visit seedsecurity.ca/en/302-canovi or email solveig.hanson@ubc.ca.

Variety images: Solveig Hanson.



Analytical Methods and Supporting Data:

CANOVI Red Nantes Carrot Trial 2022

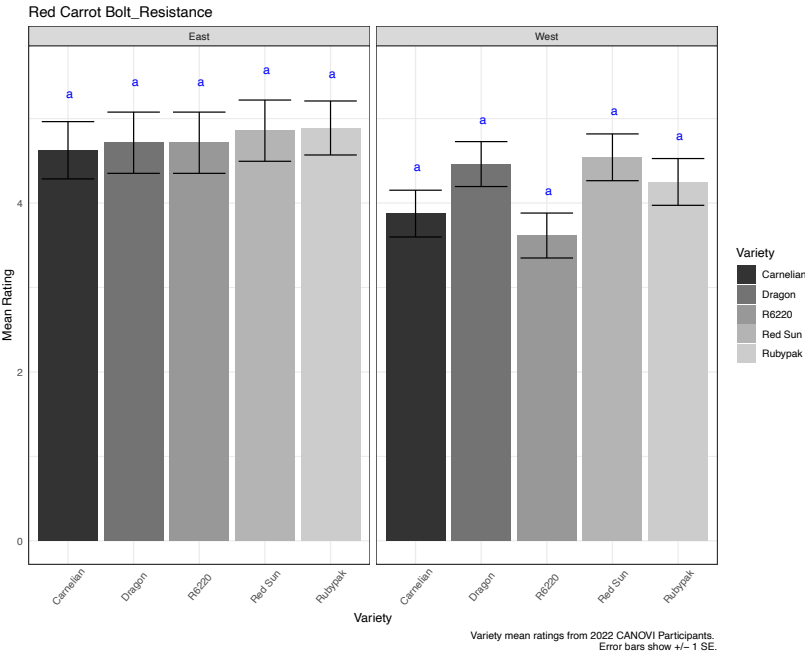
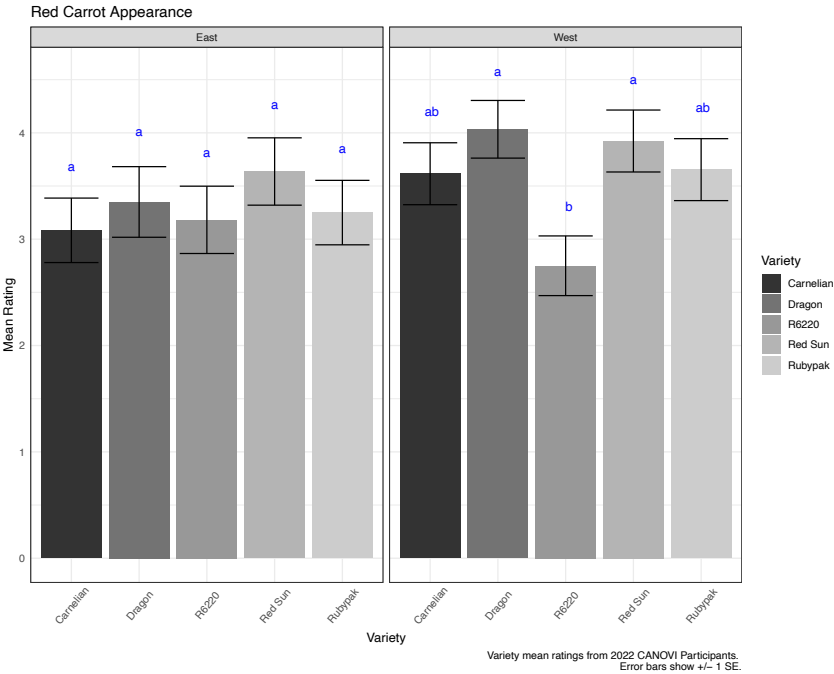
Trait ratings were analyzed by variety, region, and variety-region interaction using a **two-way fixed effects Analysis of Variance**. That is, we looked for significant differences in ratings among varieties and between East-West regions.

N = 30 participants, with $n_{\text{East}} = 13$ participants in NS, QC and ON and $n_{\text{West}} = 17$ participants in BC and AB.

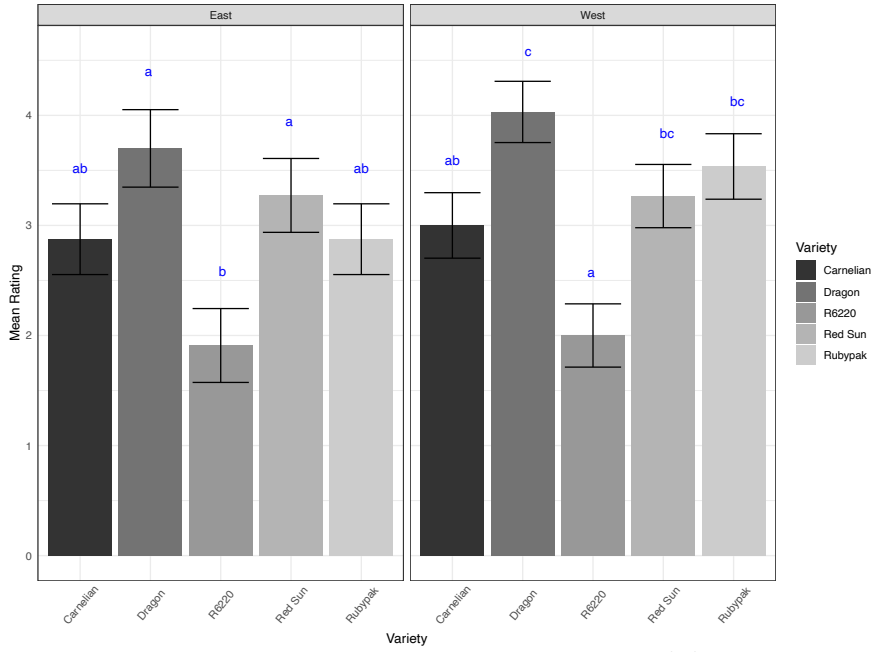
Trait	Source of Variation	DF	SS	MS	F	Pr >F Sig
Appearance	Variety	4	11.90	2.98	2.70	0.03 *
	East_West	1	2.64	2.64	2.40	0.12
	Variety:East_West	4	4.58	1.15	1.04	0.39
	Residuals	114	125.67	1.10	NA	NA
Bolt Resistance	Variety	4	6.21	1.55	1.69	0.16
	East_West	1	8.87	8.87	9.64	0.003 **
	Variety:East_West	4	2.15	0.54	0.58	0.68
	Residuals	90	82.83	0.92	NA	NA
Canopy Cover	Variety	4	52.14	13.04	10.52	2.44E-07 ***
	East_West	1	1.84	1.84	1.49	0.22
	Variety:East_West	4	1.81	0.45	0.36	0.83
	Residuals	120	148.72	1.24	NA	NA
Flavor	Variety	4	2.84	0.71	0.54	0.71
	East_West	1	0.05	0.05	0.04	0.85
	Variety:East_West	4	0.34	0.09	0.06	0.99
	Residuals	111	147.28	1.33	NA	NA
Germination	Variety	4	91.11	22.78	15.68	1.89E-10 ***
	East_West	1	7.05	7.05	4.85	0.03 *
	Variety:East_West	4	2.57	0.64	0.44	0.78
	Residuals	127	184.54	1.45	NA	NA
Marketability	Variety	4	12.99	3.25	2.38	0.06 ^
	East_West	1	3.76	3.76	2.76	0.0997 ^
	Variety:East_West	4	6.31	1.58	1.15	0.33
	Residuals	113	154.35	1.37	NA	NA
Uniformity	Variety	4	3.55	0.89	0.60	0.67
	East_West	1	0.64	0.64	0.43	0.52
	Variety:East_West	4	4.55	1.14	0.76	0.55
	Residuals	112	166.84	1.49	NA	NA
Vigor	Variety	4	64.67	16.17	14.05	2.02E-09 ***
	East_West	1	0.60	0.60	0.52	0.47
	Variety:East_West	4	4.29	1.07	0.93	0.45
	Residuals	119	136.89	1.15	NA	NA
Yield	Variety	4	48.04	12.01	8.23	6.83E-06 ***
	East_West	1	3.20	3.20	2.20	0.14
	Variety:East_West	4	1.73	0.43	0.30	0.88
	Residuals	119	173.73	1.46	NA	NA

	P (<F)	Strength of evidence
^	<0.10	Weak
*	<0.05	Moderate
**	<0.01	Strong
***	<0.001	Very strong

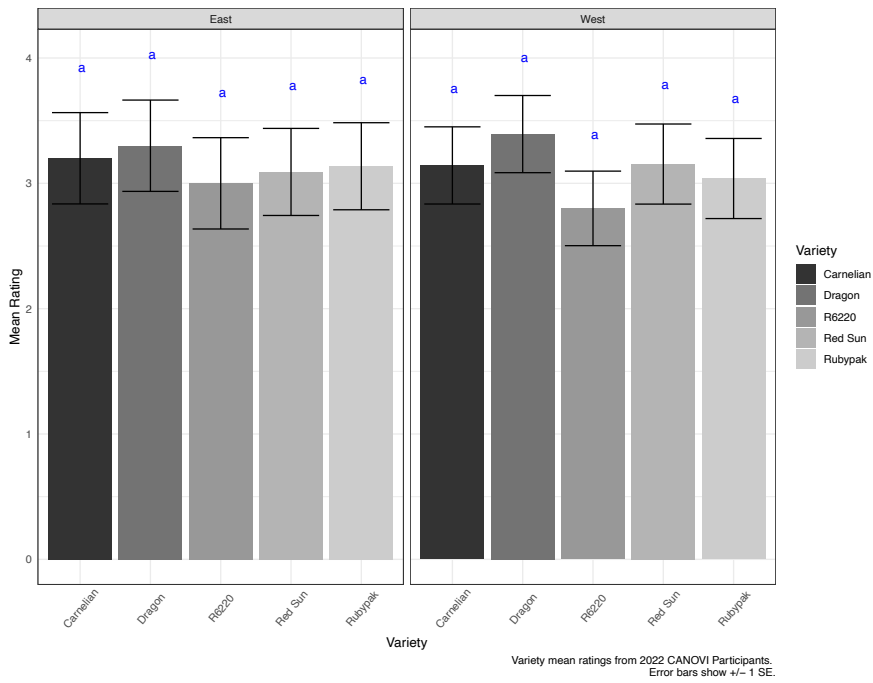
The following pages display barplots of mean ratings for each trait, with error bars showing +/- 1 SE around the mean. **Different letters denote a statistically significant difference in ratings between varieties within region at P < 0.10.** At times, a significant pairwise comparison appears within a region, even though ANOVA shows no significant variety effect.



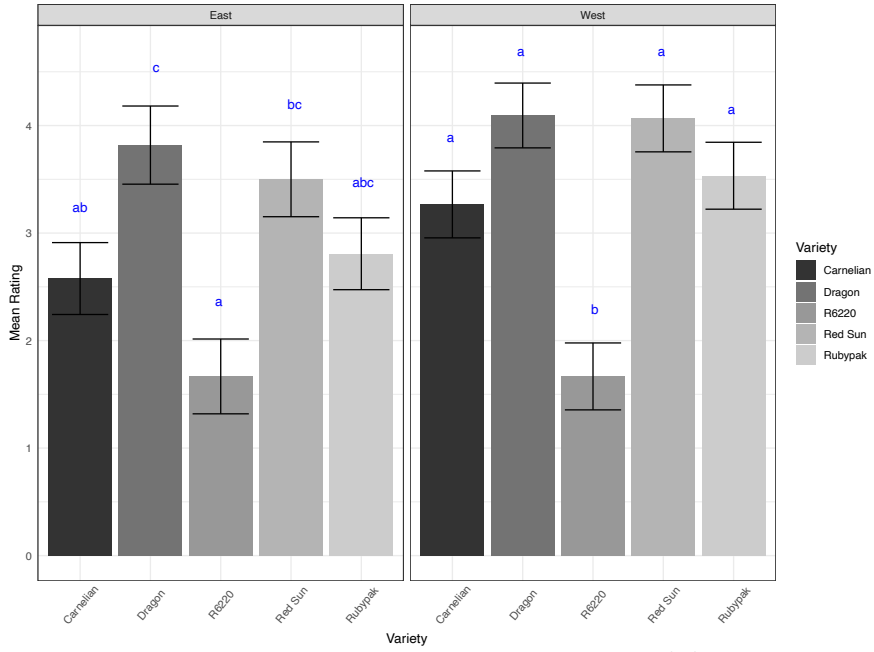
Red Carrot Canopy_Cover



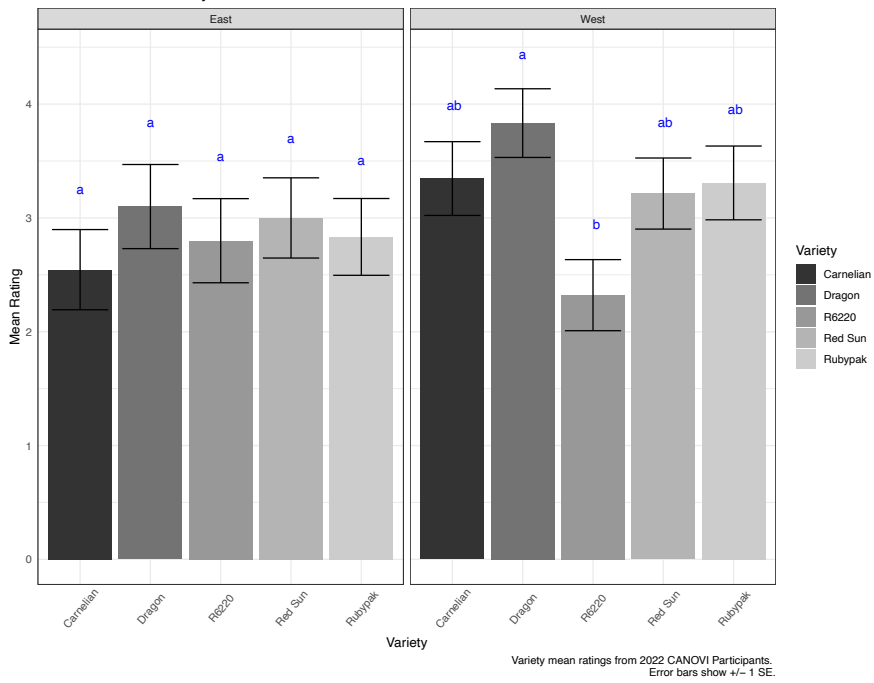
Red Carrot Flavor



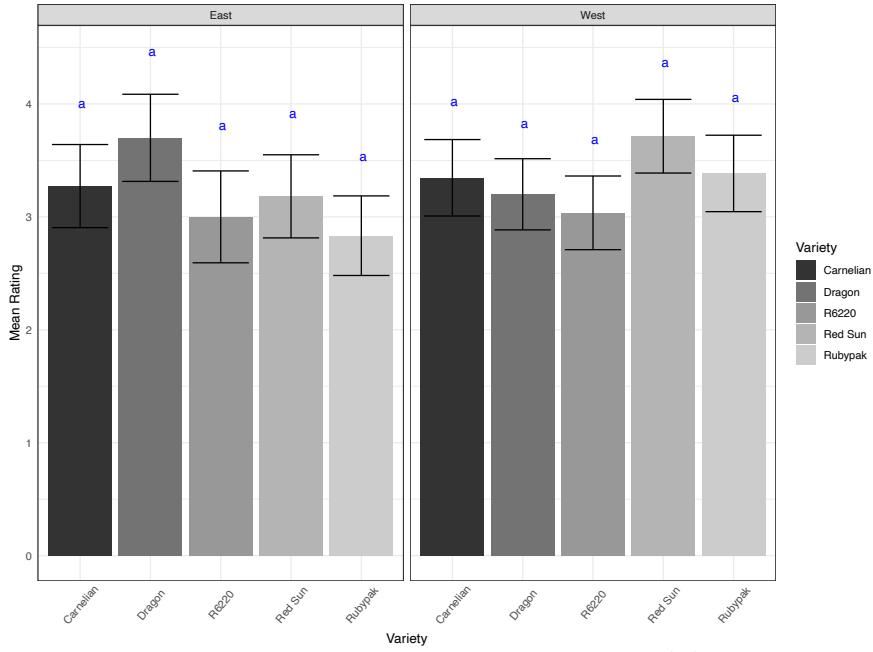
Red Carrot Germination



Red Carrot Marketability

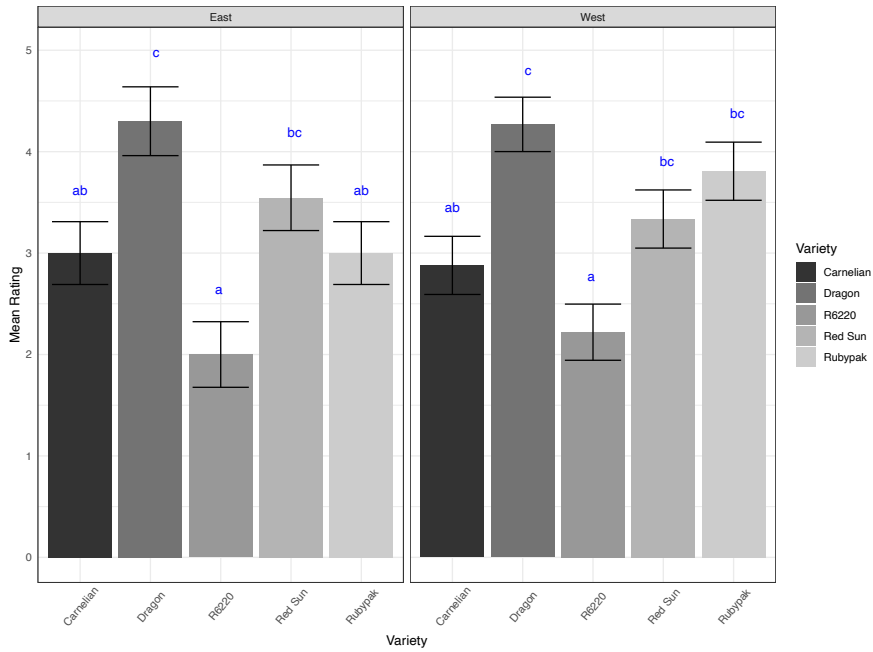


Red Carrot Uniformity

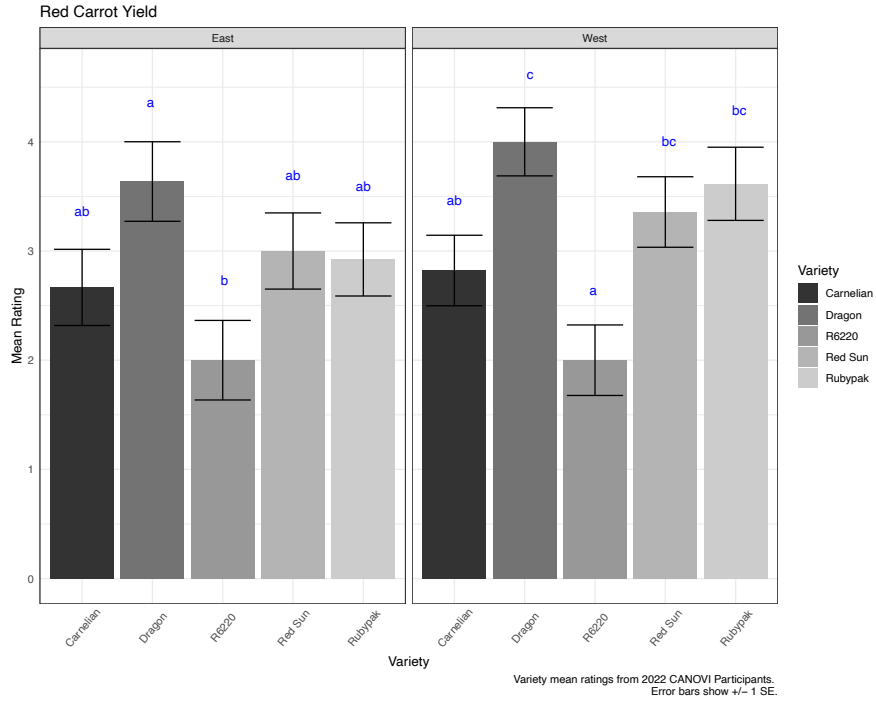


Variety mean ratings from 2022 CANOVI Participants.
Error bars show ± 1 SE.

Red Carrot Vigor



Variety mean ratings from 2022 CANOVI Participants.
Error bars show ± 1 SE.



UBC Farm Hub Site Harvest Data: CANOVI Red Carrot Trial 2022 Harvest 74 Days After Planting

Variety	Days to Maturity	Breeder	Seed Source	Appearance	Uniformity	Marketability	Yield	Flavor	Marketable Yield (Lbs)	Total Yield (Lbs)	Percent Marketable Yield
Fantasia		OSA - CIOA	OSA	4.5	3.5	4.5	4	5	2.64	3.54	75%
Dragon	70	John Navazio	Johnny's	4.5	3.5	4.5	4	5	2.62	3.52	76%
Red Sun	70	Bejo	Johnny's	4	3.5	4	5	4	2.56	3.2	80%
Rubypak	72	Bejo	Johnny's	3	3	3	4	3.5	1.44	2.01	72%
R6620		OSA - CIOA	OSA	3.5	3.5	3.5	2.5	3.5	1.3	1.67	80%
Carnelian	95	OSA - CIOA	OSA	3	3	3.5	3.5	4	1.27	2	64%

Harvest 95 Days After Planting

Variety	Days to Maturity	Breeder	Seed Source	Appearance	Uniformity	Marketability	Yield	Flavor	Marketable Yield (Lbs)	Total Yield (Lbs)	Percent Marketable Yield
R6620		OSA - CIOA	OSA	3.5	3.5	3.5	4	4	5.11	8.33	58%
Carnelian	95	OSA - CIOA	OSA	3	4	3.5	4	3	3.69	7.79	47%
Rubypak	72	Bejo	Johnny's	3.5	3	3	3	1	2.2	3.26	71%
Red Sun	70	Bejo	Johnny's	3	4	3	3.5	3.5	1.9	4.52	44%
Dragon	70	John Navazio	Johnny's	3.5	3.5	3	3	2	1.39	2.91	43%
Fantasia		OSA - CIOA	OSA	3	4	3	2	3	0.92	2.91	31%

Mean of best 2 replicates

Green = High; Yellow = Mid-range; Red = Low

Fantasia, a multicoloured population created and selected by Organic Seed Alliance (OSA) in collaboration with University of Wisconsin-Madison, showed outstanding flavour, yield, appearance, and marketability at 74 day harvest. We are working with OSA to make more seed available to Canadian farmers for on-farm selection - in a rainbow of different directions - and seed production.

Carnelian and R6220, two OP varieties selected by OSA as part of the Carrot Improvement for Organic Agriculture project, stood out for yield and flavour at 95 day harvest.