

**Executive summary:** CANOVI has been running red carrot variety trials for six years, with 2023 being the first year for trialling carrots of other specialty colours. Growers across Canada and the United States (US) (n = 44) grew six varieties of carrots and rated them on 10 agronomic traits. Out of six trialled varieties, “Fantasia” had the highest average score for every agronomic trait except bolt resistance and uniformity (although the lack of uniformity can be explained by “Fantasia” being bred to be a variable carrot population with mixed colours, sizes, and shapes). Participants also voted “Fantasia” as the top variety they would grow again. Open-pollinated specialty carrots are still in need of improved breeding for agronomic performance and vigour in different climates. We encourage participants to access SeedLinked to review which carrot varieties worked best for them, but also review other participant feedback on the performance of carrots in other farming contexts.



**Background:** The CANOVI red carrot breeding project began in 2019, in response to BC grower interest in a bolt-resistant, good tasting, smooth, and blunt-tipped red carrot. This year’s trial expanded its goal to other open-pollinated, specialty carrots to gauge their readiness for commercialization. The trial was delivered in collaboration with the Organic Seed Alliance (OSA) to offer a greater diversity of organically bred carrot lines and foster knowledge exchange and seed security across North America.

**Varieties:** We chose six varieties of specialty carrots to evaluate. All the varieties were open-pollinated, and grown in Canada or the United States.

**Results:** Variety had a significant impact on all agronomic traits except bolt resistance and flavour, according to ANOVA statistical analysis. Region and climate showed no significant effects or interactions with variety on agronomic traits. “Fantasia” overall had the highest ratings for all agronomic characteristics except bolt resistance and uniformity.

Participants most commonly voted “Fantasia” (86%), “Jaune du Doubs” (68%), and “Purple-Orange-Purple” (62%) as the varieties they would grow again.

### Average ratings (1-5) for agronomic traits across carrot varieties.

| Colour | Variety                  | Germination<br>*** | Vigour*<br>** | Canopy<br>*** | Bolt<br>Resistance | Yield<br>*** | Uniformity*<br>** | Market-<br>ability<br>*** | Appear-<br>ance*** | Flavour | Overall<br>*** |
|--------|--------------------------|--------------------|---------------|---------------|--------------------|--------------|-------------------|---------------------------|--------------------|---------|----------------|
| Mixed  | Fantasia                 | 3.6a               | 3.6a          | 3.9a          | 4.5a               | 3.8a         | 2.9a              | 3.5a                      | 3.9a               | 3.7a    | 3.6a           |
|        | Purple-Orange<br>-Purple | 2.2b               | 2.7b          | 3.1b          | 4.3a               | 2.6b         | 2.7a              | 3.0b                      | 3.4a               | 3.2a    | 2.7b           |
| Yellow | Jaune du<br>Doubs        | 3.4a               | 3.5a          | 3.9a          | 4.6a               | 3.5a         | 3.5a              | 3.3a                      | 3.4a               | 3.0a    | 3.3a           |
|        | Y1246                    | 1.4b               | 1.9b          | 2.1b          | 4.4a               | 1.6b         | 2.4b              | 2.0b                      | 2.3b               | 3.2a    | 2.0b           |
| Red    | Carnelian                | 3.4a               | 3.2a          | 3.2a          | 4.6a               | 2.9a         | 3.3a              | 3.3a                      | 3.7a               | 3.4a    | 3.3a           |
|        | R6220                    | 3.3a               | 3.2a          | 3.2a          | 4.5a               | 2.9a         | 3.3a              | 3.1a                      | 3.5a               | 2.9a    | 3.1a           |

Darker green colour = higher score, and yellow colour = lower score.

Different letters indicate the significant difference of ratings between the two varieties in each colour group.

**Takeaways and next steps:** “Fantasia” was the strongest performing variety, while “Y1246” was the poorest performing variety. The variable performance across specialty carrot varieties and their traits may be explained by the certain varieties being bred for both genetic and phenotypic diversity.

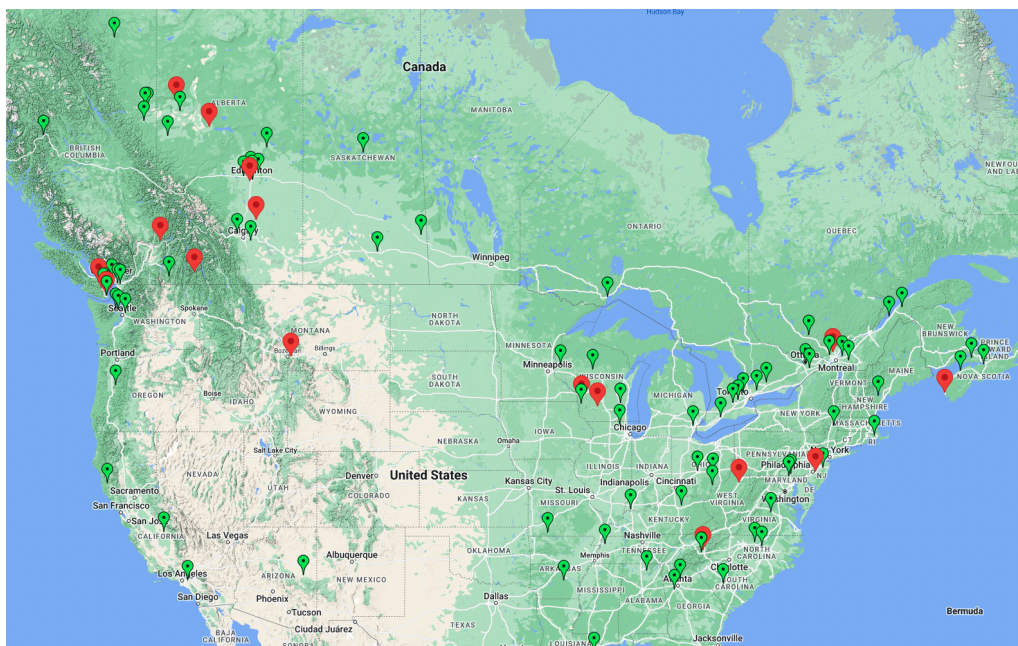
Open-pollinated specialty carrots are still in need of improved breeding for agronomic performance and vigour in different climates. Germination, vigour, and uniformity of all varieties could specifically use improvement. Seed growers in these trials develop more skills and experience in the variety development process that can increase the overall quality of the seed varieties they produce. Through these collaborative variety trials, growers and breeders create a positive feedback loop in the variety development process that strengthens organic seed production systems.

We encourage participants to access SeedLinked to review which carrot varieties worked best for them in their specific regional climate and farming systems. Given how variable performance was across varieties, we also encourage participants to access observations and photos from other participants to see how carrots performed in other farming contexts.

### More results can be found in full report below

## Participant Locations

This study included 85 participants across Canada and the United States (Figure 1) with 50 marked as completed trials on Seedlinked (59% completion). We removed four of the completed trials (three from Canada and one from the US) from data analysis due to missing or questionable data; therefore, 31 Canadian trials and 15 US trials ( $n_{\text{total}} = 46$ ) were used in the data analysis. The University of British Columbia (UBC) Organic Farm acted as the “mother site” of this trial, as researchers there sowed triplicate plots of each variety for observation.



**Figure 1. Geographical spread of CANOVI specialty carrot participants across Canada and the United States.** Each location mark is a participant accepted to the trial. Green mark indicates active trials and red indicates inactive trials.

## Carrot Varieties

Table 1 shows the full list of the carrot varieties we selected for this study with their colour and seed source information. Organic Seed Alliance provided all the carrot varieties except “Jaune de Doubs,” which was an heirloom variety.

**Table 1. List of carrot varieties included in this study.** Days to Maturity are listed as “N/A” (not available) for the CANOVI and Organic Seed Alliance (OSA) varieties, as they have not been defined yet.

| Variety  | Colour(s)          | OP / F1 /<br>Breeding<br>Line | Days to<br>Maturity | Breeder                  | Seed Source                           |
|----------|--------------------|-------------------------------|---------------------|--------------------------|---------------------------------------|
| Fantasia | Multi-<br>coloured | OP                            | N/A                 | Organic Seed<br>Alliance | <a href="#">Organic Seed Alliance</a> |

|                             |                   |                        |                   |                          |  |
|-----------------------------|-------------------|------------------------|-------------------|--------------------------|--|
| OSA<br>Purple/Orange/Purple | Purple/<br>Orange | Breeding<br>Population | N/A               | Organic Seed<br>Alliance | <a href="#">Organic Seed Alliance</a>  |
| Y1246                       | Yellow            | Breeding<br>Population | N/A               | Organic Seed<br>Alliance | <a href="#">Organic Seed Alliance</a>  |
| Jaune de Doubs              | Yellow            | OP                     | 130 - 150<br>days | Heirloom                 | <a href="#">La Société Des Plantes</a> |
| Carnelian                   | Red               | OP                     | N/A               | Organic Seed<br>Alliance | <a href="#">Organic Seed Alliance</a>  |
| R6220                       | Red               | Breeding<br>Population | N/A               | Organic Seed<br>Alliance | <a href="#">Organic Seed Alliance</a>  |

## Planting

We asked participants to plant 12 linear feet of carrots 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 to October. Participants used their usual organic methods for soil fertility and weed management.

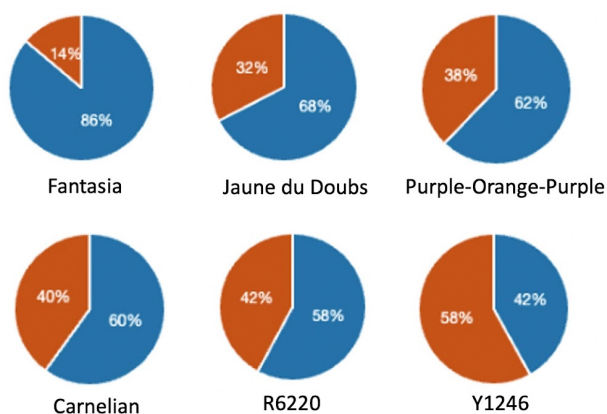
## Evaluation

Participants evaluated varieties using the desktop or mobile [SeedLinked app](#) for germination, vigour, canopy closure, yield, bolt resistance, uniformity, marketability, appearance, flavour, and overall performance on a scale of 1 (low) to 5 (high). We provided a rubric that defined the rating scale for each trait. Further planting and evaluation details are available in the [2023 Carrot Trial Protocol](#).

## Analysis

Evaluation summaries were available on the SeedLinked website immediately after trial closure. In addition, CANOVI researchers performed statistical analysis and presented results in this trial report.

## Would you grow this again?

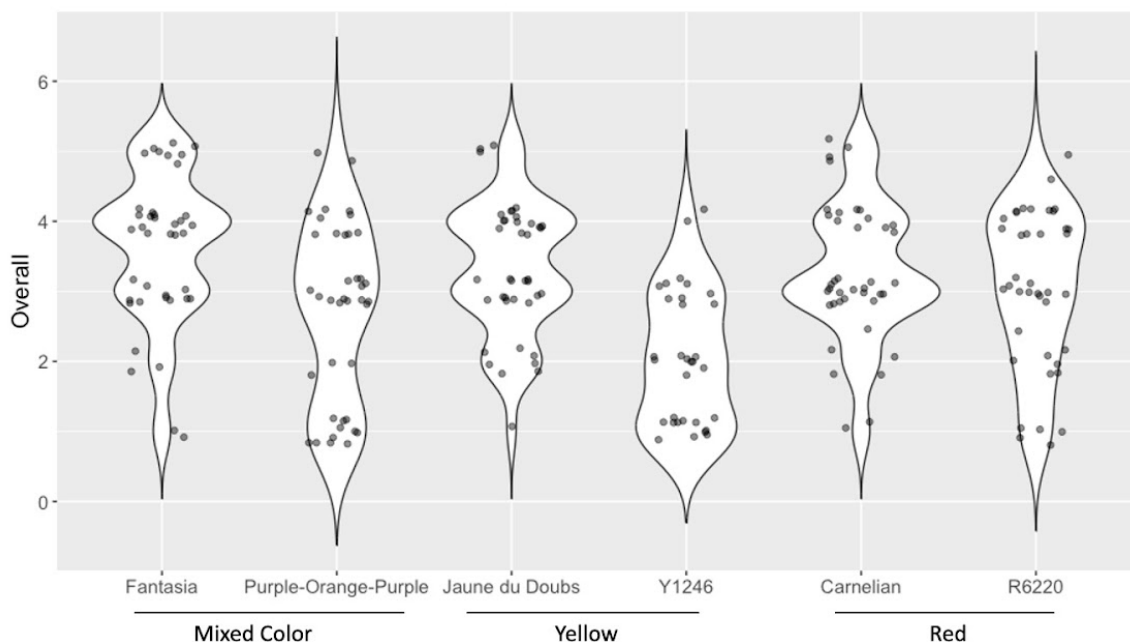


**Figure 2. Percentage of participants who voted to grow a carrot variety again.** Red depicts the percentage of participants who would **not** grow a variety again, while blue depicts that percentage of participants who would grow a variety again.

We asked participants which carrot varieties they would grow again, with a summary of results available in Figure 2. Overall, participants most commonly voted “Fantasia” (86%), “Jaune du Doubs” (68%), and “Purple-Orange-Purple” (62%) as the varieties they would grow again.

### Distribution of “Overall Performance” Rating by Varieties

We asked all participants to rate the overall performance of varieties from 1 (low) - 5 (high). Figure 3 depicts the ratings for overall variety performance. In the two multi-colored varieties, “Fantasia” had better overall performance than “Purple-Orange-Purple” which had more ratings in 1 and 3. In the two yellow varieties, “Jaune du Doubs” had better overall performance than “Y1246” whose ratings were distributed mainly in 1-3. In the two red varieties, “Carnelian” and “R6220” both had most ratings in 3 and 4, but the latter had more ratings in 1- 2 range.



**Figure 3. Distribution of overall performance ratings (1-5) of carrot varieties across participants.** Dots on the bars represent individual ratings.

### Effect of Variety and Region on Agronomic Traits

Analysis of variance (ANOVA) indicated that variety had a significant impact on germination, vigour, canopy closure, yield, uniformity, marketability, appearance, and overall performance, but no significant impact on bolt resistance nor flavour (Table 2).

Researchers grouped participants into three different growing regions which were Eastern Canada (n = 12, Canadian provinces east of Manitoba), Western Canada (n = 19, Canadian provinces west of Manitoba), and the US (n = 15, all states in the US). Region had no significant effect on any agronomic traits except canopy. The interaction between variety and region also did not produce a significant effect for any agronomic traits (Table 2).

**Table 2. Summary of ANOVA analyses on the effect of variety, region and their interaction on the agronomic performance of all trials.** Region includes Eastern Canada, Western Canada, and the US.

| Variable         | Germination | Vigor | Canopy | Bolt Resistance | Yield | Uniformity | Marketability | Appearance | Flavour | Overall |
|------------------|-------------|-------|--------|-----------------|-------|------------|---------------|------------|---------|---------|
| Variety          | ***         | ***   | ***    | -               | ***   | ***        | ***           | ***        | -       | ***     |
| Region           | -           | -     | *      | -               | -     | -          | -             | -          | -       | -       |
| Variety x Region | -           | -     | -      | -               | -     | -          | -             | -          | -       | -       |

Significant level: p-value <0.001\*\*\*, <0.01\*\*, p-value < 0.05 \*, no significance “-”.

The agronomic performance of each variety is listed in Table 3. Overall, “Fantasia” had the highest overall performance score, with it also having the highest average ratings for all agronomic traits except uniformity and bolt resistance. The low uniformity rating for “Fantasia” may be explained by the variety purposefully being bred to be a variable carrot population with mixed colours, sizes, and shapes. “Y1246” performed the worst among varieties with the lowest rating scores across all agronomic traits except uniformity.

For mixed multi-colored carrot varieties, “Fantasia” had higher ratings than “Purple-Orange-Purple” for every agronomic trait. For yellow carrot varieties, “Jaune du Doubs” had higher ratings than “Y1246” for every agronomic trait except flavour. For the red carrot varieties, “Carnelian” and “R6220” had similar ratings for each agronomic trait except for flavour, where “Carnelian” had a higher rating.

**Table 3. Average ratings (1-5) for agronomic traits across carrot varieties.**

| Colour | Variety              | Germination | Vigour | Canopy | Bolt Resistance | Yield | Uniformity | Marketability | Appearance | Flavour | Overall |
|--------|----------------------|-------------|--------|--------|-----------------|-------|------------|---------------|------------|---------|---------|
| Mixed  | Fantasia             | 3.6a        | 3.6a   | 3.9a   | 4.5a            | 3.8a  | 2.9a       | 3.5a          | 3.9a       | 3.7a    | 3.6a    |
|        | Purple-Orange-Purple | 2.2b        | 2.7b   | 3.1b   | 4.3a            | 2.6b  | 2.7a       | 3.0b          | 3.4a       | 3.2a    | 2.7b    |
| Yellow | Jaune du Doubs       | 3.4a        | 3.5a   | 3.9a   | 4.6a            | 3.5a  | 3.5a       | 3.3a          | 3.4a       | 3.0a    | 3.3a    |
|        | Y1246                | 1.4b        | 1.9b   | 2.1b   | 4.4a            | 1.6b  | 2.4b       | 2.0b          | 2.3b       | 3.2a    | 2.0b    |
| Red    | Carnelian            | 3.4a        | 3.2a   | 3.2a   | 4.6a            | 2.9a  | 3.3a       | 3.3a          | 3.7a       | 3.4a    | 3.3a    |
|        | R6220                | 3.3a        | 3.2a   | 3.2a   | 4.5a            | 2.9a  | 3.3a       | 3.1a          | 3.5a       | 2.9a    | 3.1a    |

Darker green colour = higher score, and yellow colour = lower score.

Different letters indicate the significant difference of ratings between the two varieties in each colour group.

## Effect of Variety and Climate on Agronomic Traits

Among the 46 completed trials, there were 25 trials that had climate data. Researchers grouped data from these trials into different climate types, including average climate (n = 9), drought (n = 9) and excessive rain (n = 7).

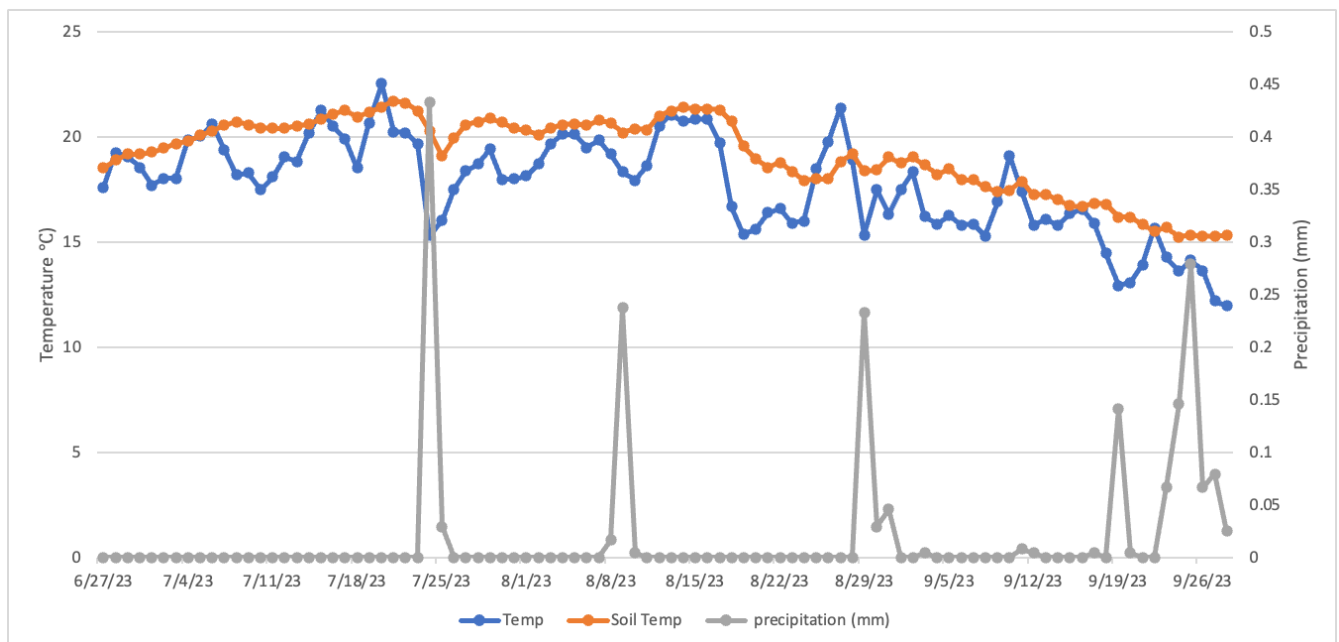
Researchers conducted ANOVA on the subset of data with climate information to test the effect of variety, climate, and their interaction. There was no significant effect of climate on any agronomic traits, and no significant interaction between variety and climate (Table 4).

**Table 4. Summary of ANOVA analyses on the effect of variety, climate and their interaction on the agronomic performance of selected trials.** Climate data was split up by average climate, drought or excessive rain.

| Variable          | Germination | Vigour | Canopy | Bolt Resistance | Yield | Uniformity | Marketability | Appearance | Flavour | Overall |
|-------------------|-------------|--------|--------|-----------------|-------|------------|---------------|------------|---------|---------|
| Variety           | ***         | ***    | ***    | -               | ***   | **         | ***           | ***        | -       | ***     |
| Climate           | -           | -      | -      | -               | -     | -          | -             | -          | -       | -       |
| Variety x Climate | -           | -      | -      | -               | -     | -          | -             | -          | -       | -       |

### UBC Organic Farm Mother Site

The climatic conditions at the UBC mother site is shown in Figure 4. The daily average temperature and precipitation was recorded from June 27, 2023, which was the day carrot seeds were sown, to September 28, 2023, which was the day the carrots were harvested. The graph shows the average daily temperature at the mother site. Researchers irrigated plots when needed.



**Figure 4. Average temperature (°C), soil temperature (°C), and precipitation (mm) at UBC Organic Farm of each day during the carrot growing season.**

At the UBC mother site, researchers planted three replicated plots for each variety. Researchers rated each plot for germination (on July 20), vigour (August 8), and canopy closure with the scale of 1-5. Researchers rated canopy closure two times observationally on August 15 and August 23, and one time on August 23 using the “Canopeo” App to obtain the percentage of leaf coverage in each plot. The ratings from two canopy closure assessments were not significantly different, thus the average of the two ratings were used to present.

On harvest day, the roots of each variety in each plot were rated for uniformity, marketability, appearance, flavour, and overall performance. Two researchers combined roots from all three plots and evaluated them for flavour. The average rating of all replicates for each variety is presented in Table 5.

**Table 5. Average ratings for agronomic traits across varieties at UBC Organic Farm.** Ratings were the average of the three replicates and the two canopy assessments.

| Colour | Variety              | Germination | Vigour | Canopy | Canopy Percentage | Uniformity | Marketability | Appearance | Flavour | Overall |
|--------|----------------------|-------------|--------|--------|-------------------|------------|---------------|------------|---------|---------|
| Mixed  | Fantasia             | 3.8         | 4.0    | 4.3    | 63.3%             | 1.0        | 4.2           | 4.2        | 2.8     | 3.5     |
|        | Purple-Orange-Purple | 2.0         | 3.2    | 3.8    | 53.3%             | 2.3        | 3.3           | 3.0        | 2.5     | 3.0     |
| Yellow | Jaune du Doubs       | 5.0         | 4.5    | 4.4    | 66.7%             | 3.0        | 2.7           | 3.0        | 2.8     | 2.5     |
|        | Y1246                | 1.0         | 2.2    | 3.2    | 40.0%             | 3.3        | 3.3           | 3.7        | 3.0     | 3.0     |
| Red    | Carnelian            | 4.7         | 4.3    | 4.3    | 56.7%             | 3.8        | 3.7           | 3.5        | 3.8     | 3.5     |
|        | R6220                | 4.3         | 3.8    | 4.1    | 60.0%             | 3.7        | 4.2           | 4.2        | 2.5     | 2.3     |

Darker green colour = higher score, yellow colour = lower score;

At the UBC mother site, the varieties were not rated for yield with the 1-5 scale. Instead, the roots were counted as total root count and marketable root count, and the counted roots were weighted. The results are listed in table 6. The yellow variety “Jaune du Doubs” had the highest marketable root weight and percent marketable roots (number of marketable roots / number of total roots). The yellow variety “Y1246” and red variety “R6220” had lowest marketable root weight and percent marketable root.

**Table 6. Average root count and root weight of each variety.**

| Colour | Variety              | Root Count |            | Root Weight (lb) |            | Percent Marketable Root |
|--------|----------------------|------------|------------|------------------|------------|-------------------------|
|        |                      | Total      | Marketable | Total            | Marketable |                         |
| Mixed  | Fantasia             | 39         | 29         | 11.93            | 9.15       | 73.7%                   |
|        | Purple-Orange-Purple | 25         | 18         | 8.72             | 6.47       | 72.4%                   |



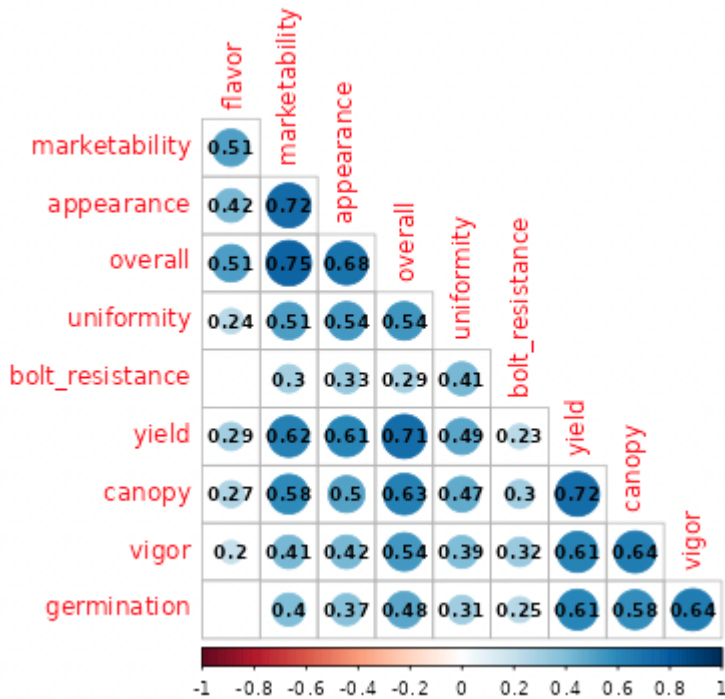
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|        |                |    |    |       |       |       |
|--------|----------------|----|----|-------|-------|-------|
| Yellow | Jaune du Doubs | 41 | 37 | 11.78 | 10.01 | 91.8% |
|        | Y1246          | 16 | 7  | 6.57  | 2.92  | 46.8% |
| Red    | Carnelian      | 48 | 37 | 8.70  | 7.30  | 77.2% |
|        | R6220          | 32 | 12 | 4.78  | 2.03  | 36.1% |

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## Supplemental materials

### Correlation of Agronomic Characteristics



**Figure 5. Correlation matrix between agronomic traits.** Darker colours indicate a higher correlation between any two traits and the r-values (on each dot) indicate the strength (higher the stronger) and directionality (positive vs. negative) of the correlation.

### Carrot Tasting Results

Carrot tasting was conducted at the Feast at Fields event on September 9, 2023. Attendees tasted three specialty carrots, including “Jaune du Doubs” (yellow), “R5646” (red), and “Purple-Orange-Purple.” A total of 22 attendees tasted and rated the carrots on appearance, texture, and flavour on a scale of 1-5 (low - high) (Table 7).

**Table 7. Average ratings of CANOVI specialty carrot varieties by attendees at Feast at Fields.**

| Variety              | Appearance | Texture | Flavour |
|----------------------|------------|---------|---------|
| Jaune du Doubs       | 3.95       | 3.90    | 3.64    |
| R5646                | 4.20       | 4.05    | 3.62    |
| Purple-Orange-Purple | 4.25       | 4.00    | 3.22    |

Another carrot tasting was conducted at UBC Organic Farm on September 16, 2023. Another three specialty carrots were tasted including “R6220” (red), “Y1246” (yellow), and “Fantasia” (multi-coloured). A total of 61 participants tasted and rated the samples for appearance, texture, and flavour with the same 1-5 scale (Table 8)

**Table 8. Average ratings of CANOVI specialty carrot varieties by participants at UBC Organic Farm on September 16, 2023.**

| Variety  | Appearance | Texture | Flavour |
|----------|------------|---------|---------|
| R6220    | 3.82       | 3.78    | 3.42    |
| Y1246    | 3.95       | 4.13    | 4.05    |
| Fantasia | 4.21       | 4.16    | 3.79    |

### University of Toronto Scarborough (UTSC) Ontario Mother site

At the Ontario mother site at UTSC, researchers grew three replicates of each specialty carrot variety. Researchers rated each replicate for all agronomic traits on the scale of 1-5. The site reported excessive rain at the establishment period which could have affected germination. The site also reported that the uniformity was abnormally poor and could be due to tilling practices.

**Table 9. Average ratings for agronomic traits across varieties at the UTSC mother site.** Ratings were the average of the three replicates. “NA” denotes missing data.

| Colour | Variety              | Germination | Vigour | Canopy | Yield | Uniformity | Marketability | Appearance | Flavour | Overall |
|--------|----------------------|-------------|--------|--------|-------|------------|---------------|------------|---------|---------|
| Mixed  | Fantasia             | 2.0         | 4.0    | 4.0    | 2.3   | 1.0        | 1.7           | 2.0        | 3.3     | 2.0     |
|        | Purple-Orange-Purple | 1.0         | 3.0    | 4.0    | 1.0   | 1.3        | 1.0           | 1.0        | 2.8     | 1.0     |
| Yellow | Jaune du Doubs       | 2.0         | 3.0    | 4.0    | 3.0   | 2.0        | 2.0           | 2.0        | 1.7     | 2.0     |
|        | Y1246                | 1.0         | 1.3    | 1.3    | 1.0   | 1.7        | 1.3           | 1.0        | 1.3     | 1.0     |
| Red    | Carnelian            | 2.3         | 2.0    | NA     | 2.3   | 2.0        | 1.7           | 2.0        | 3.0     | 1.7     |
|        | R6220                | 2.0         | 3.0    | NA     | 2.0   | 2.0        | 1.0           | 2.0        | 1.7     | 1.0     |

1. Darker green colour = higher score, yellow colour = lower score