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This report represents the first effort to document information about plant breeding priorities that was previously only available anecdotally. More extensive research with an effort to improve response rates would further substantiate the findings presented here. However, when viewed alongside regional approaches to priority setting for plant breeding, the survey results can provide a broader national context for participatory organic/ ecological vegetable breeding. We hope it will be useful for farmers, seed growers, and plant breeders who are interested in developing regional varieties that meet the needs of the organic/ ecological vegetable farming community in Canada and beyond.

For this survey, farmers across Canada were invited to participate through online invitations from national and regional farming organizations. Of seventy-one farmers who responded, all were either certified organic, used ecological farming principles, and/or used integrated pest management. The majority of respondents had 5 acres or less of vegetables in production. Most respondents grew vegetables for commercial sale, and many grew seed for commercial sale and/or on-farm use.

HIGHLIGHTED RESULTS

- Some of the most important crop traits according to respondents were flavour, productivity, early harvest, and disease resistance. Of these, flavour was a standout in terms of respondent priorities.
- The seven crops most frequently selected as needing plant breeding improvement were tomatoes, peppers, carrots, lettuce, winter squash, onions/leeks, and broccoli/cauliflower.
- Major marketing venues for vegetable farmers were direct sales to customers, including community supported agriculture and farmers’ markets.
- The majority of farmers who sold vegetable seed commercially used small-packet direct marketing as a major marketing channel, while fewer used bulk wholesale or small-packet wholesale, or bulk direct marketing.
- Some farmers suggested that marketing channels for both vegetables and vegetable seeds had some effect on their breeding priorities. For example, factors such as taste, uniqueness, and diversity influence variety choices of farmers and seed growers.
- The results from this survey align with similar surveys distributed in the U.S. with some regional differences related to crop preferences and priority traits, and specific pests/disease issues.

Although the results of this survey must be interpreted cautiously in light of low response rates, this report represents a preliminary effort to document information about plant breeding priorities that was previously only available anecdotally. More extensive research with an effort to improve response rates would further substantiate the findings presented here. However, when viewed alongside regional approaches to priority setting for plant breeding, the survey results can provide a broader national context for participatory organic/ ecological vegetable breeding. We hope it will be useful for farmers, seed growers, and plant breeders who are interested in developing regional varieties that meet the needs of the organic/ ecological vegetable farming community in Canada and beyond.
INTRODUCTION

Farmers that practice organic/ecological production require varieties that are bred to perform well in their unique farming systems. It is increasingly recognized that crop varieties that are adapted to ecological production systems are crucial to farmers’ ability to minimize environmental impacts and adapt to climate change (Lammerts van Bueren et al. 2011; Entz et al. 2015). However, the majority of plant breeding in North America is focused on high-input and intensive agricultural systems in major production regions. Varieties bred to be high yielding in ideal growing conditions with standard inputs may not be well suited to production in less-than-ideal conditions or with minimal inputs guided by an ecological approach (Shelton and Tracy 2017).

Canadian growers rely heavily on international seed companies that are not necessarily breeding or selecting varieties for adaptation to regional farming systems across Canada, or to organic/ecological systems (Levert 2014). Dependence on seed companies outside of Canada limits farmers’ options in terms of available varieties and makes them increasingly vulnerable to international political and economic dynamics. Additionally, the needs of growers in northern climates in Canada are likely to differ from those in lower latitudes, most obviously in the importance of adaptation to shorter growing seasons. Organic/ecological farmers may be particularly disadvantaged by this situation, because research suggests that regional adaptation can be more important for organic/ecological than conventional systems (Crespo-Herrera and Ortiz 2015).

Qualities such as pest and disease tolerance, early vigour, weed competitiveness, and flavour are valued across the vegetable farming sector, but are particularly important for certified organic farms or growers who aim to reduce the use of pesticides and synthetic fertilizers (Brouwer and Colley 2016). Awareness of the need for improved crop varieties for organic/ecological farms has led to renewed plant breeding efforts, particularly in the public sector in the United States (US) and Europe (Shelton and Tracy 2015).

Developing varieties that are better adapted to organic/ecological management in Canada requires more detailed information about farmer needs and priorities. As a first step towards servicing the plant breeding and variety development needs of Canadian organic/ecological growers, The Bauta Family Initiative on Canadian Seed Security and the University of British Columbia Centre for Sustainable Food Systems partnered on the Canadian Vegetable Plant Breeding Priorities Survey.

This report presents some of the key findings of the survey. Additional results, as well as an open-access dataset are available online through the UBC Centre of Sustainable Food Systems Dataverse platform. This report provides insight into priorities for vegetable crop breeding efforts, including identifying varieties that have been performing well in organic/ecological conditions in Canada, as well as traits that need further improvement. Although this survey is focused on organic/ecological vegetable producers, we hope that that the results are useful for all vegetable farmers and plant breeders that are interested in creating varieties that can excel in the diversity of Canadian farming conditions.

Throughout this report, the terms “organic and/or ecological” are used to include both farmers who are certified organic in Canada and farmers who employ a range of practices that are consistent with the principles of organic farming, but have chosen not to certify. Ecological farming includes, but is not limited to practices such as organic, biodynamic, permaculture, and other types of cropping systems that work to restore soil health, improve biodiversity, and find alternatives to synthetic or environmentally adverse inputs for agriculture.
METHODS

Survey questions and design were based on similar surveys conducted in other regions, including by Cornell University (Hultengren, Glos, and Mazourek 2016), University of Wisconsin-Madison (Dawson, Healy, and McCluskey, 2017), and by the Organic Seed Alliance (Brower and Colley, 2016). Researchers who had been involved with these respective studies provided an external review of the survey questions. In addition, five farmers provided feedback on a pilot version of the survey.

DISTRIBUTION

The survey was distributed online, and was designed and administered using the UBC Survey Tool provided by Qualtrics. The online invitation to participate was sent to national organic/ecological farming associations (e.g. Canadian Organic Growers, Canadian Organic Trade Association, etc.), and regional associations (e.g. Atlantic Canadian Organic Regional Network, Ecological Farmers Association of Ontario, Certified Organic Associations of British Columbia, etc.). These groups distributed the survey to their constituencies via electronic newsletters, email list-serves, and other online and social media channels. Survey responses were gathered from January 12 to March 3, 2018.

Direct emails were also sent to existing contacts of The Bauta Family Initiative on Canadian Seed Security, and its partners and farmers involved in organic/ecological vegetable production, vegetable seed production, variety trials, and plant breeding initiatives. Several agricultural organizations not focused primarily on organic/ecological production also distributed the survey, including the National Farmers Union, the Horticulture Council of Canada, and Young Agrarians. Approximately 800 vegetable farmers and vegetable seed producers received invitations to participate in the survey. This survey was not distributed widely to producers in Quebec, as L’Union des producteurs agricole (UPA) released a similar survey to Quebec producers at an earlier date. Data from the Quebec survey has been reviewed as part of this report.

RESULTS

RESPONSE AND DEMOGRAPHICS

Overall, 71 farmers who grew vegetables and/or vegetable seed in Canada responded to the survey, an estimated response rate of 8%. Most responses were from British Columbia (BC) or Ontario, which was expected because these regions account for a large number of organic/ecological vegetable farms in Canada (Table 1). Quebec is also home to many vegetable farms, but this survey was not distributed in Quebec because of the recent UPA survey. This accounts for the low number of respondents from Quebec. Even though this response rate is low, there was good geographic distribution from the main vegetable growing regions in BC and Ontario, and this survey illustrates the diversity of regional needs and priorities within these regions.
Table 1. Survey responses by region

<table>
<thead>
<tr>
<th>Region</th>
<th>Count</th>
<th>% of 71 Total Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>British Columbia</td>
<td>26</td>
<td>36.6</td>
</tr>
<tr>
<td>Prairies</td>
<td>8</td>
<td>11.3</td>
</tr>
<tr>
<td>Ontario</td>
<td>26</td>
<td>36.6</td>
</tr>
<tr>
<td>Quebec*</td>
<td>2</td>
<td>2.8</td>
</tr>
<tr>
<td>Atlantic Canada</td>
<td>7</td>
<td>9.9</td>
</tr>
<tr>
<td>Unknown</td>
<td>2</td>
<td>2.8</td>
</tr>
</tbody>
</table>

- About 65% grew vegetables for commercial sale, almost half grew seed for on-farm use, and about 30% grew seed for commercial sale.
- Farmers were asked to select all of the growing practices that applied to them, and all respondents selected at least one of these three: certified organic, ecological principles, and/or integrated pest management.
- Almost half of the respondents followed ecological principles, and almost 40% were certified organic (Table 2).
- Around 30% of respondents used integrated pest management and 30% used permaculture principles.

Table 2. Organic/ecological practices used by survey respondents

<table>
<thead>
<tr>
<th>Practice</th>
<th>Count</th>
<th>% of 71 Total Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certified organic</td>
<td>28</td>
<td>39.4</td>
</tr>
<tr>
<td>Certified biodynamic</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Certified naturally grown</td>
<td>3</td>
<td>4.2</td>
</tr>
<tr>
<td>Follows ecological practices</td>
<td>35</td>
<td>49.3</td>
</tr>
<tr>
<td>Uses integrated pest management</td>
<td>23</td>
<td>32.4</td>
</tr>
<tr>
<td>Follows permaculture principles</td>
<td>21</td>
<td>29.6</td>
</tr>
<tr>
<td>Other (please describe):</td>
<td>18</td>
<td>25.4</td>
</tr>
</tbody>
</table>

- As shown in Figure 1, 45% of respondents farmed 1 to 5 acres of vegetables, and 34% farmed less than one acre in vegetables.
- Only about 5% had more than 20 acres in vegetables.
**IMPORTANT TRAITS AND PRIORITY CROPS**

Respondents were asked to select up to five priority traits/attributes they look for in a vegetable variety for their farm, from a list provided in the survey question. The list of traits in the question was adopted from the surveys conducted by Organic Seed Alliance (Hubbard and Zy stro, 2016) and University of Wisconsin- Madison (Lyon et al. 2015), and are also traits that are commonly addressed through vegetable plant breeding and variety development. Open-ended comment fields were provided for respondents to write in additional traits. Flavour/eating quality was the most frequently selected attribute (79%), followed by productivity/yield (59%), earliness/days to maturity (48%) and disease resistance (44%). Table 3 provides a full list of the trait options from most to least frequently selected.

**Table 3. Overall trait priorities**

<table>
<thead>
<tr>
<th>Priority Trait</th>
<th>% of 71 Total Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flavour/eating quality</td>
<td>79</td>
</tr>
<tr>
<td>Productivity/yield</td>
<td>59</td>
</tr>
<tr>
<td>Earliness/days to maturity</td>
<td>48</td>
</tr>
<tr>
<td>Disease resistance</td>
<td>44</td>
</tr>
<tr>
<td>Temperature tolerance</td>
<td>28</td>
</tr>
<tr>
<td>Visual appeal</td>
<td>20</td>
</tr>
<tr>
<td>Pest resistance</td>
<td>13</td>
</tr>
<tr>
<td>Transport/storage quality</td>
<td>10</td>
</tr>
<tr>
<td>Ease of harvest</td>
<td>9</td>
</tr>
<tr>
<td>Other²</td>
<td>24</td>
</tr>
</tbody>
</table>

²Other attributes listed by farmers included: open-pollinated, bred for organic, heirloom, nutrient density, germination rate, uniformity, hardiness, year after year supply, ability to grow in forest, resilience to precipitation variability, and marketability.
Respondents were also asked to provide comments about individual vegetable crops. First, they were asked to select as many crops as they wanted that are in need of improvement through plant breeding from a list of commonly grown vegetable crops, with an option for writing additional crops. Crops listed in the survey question included:

- Lettuce
- Tomato
- Pepper
- Eggplant
- Broccoli/Cauliflower
- Cabbage
- Kale/Collards
- Winter Squash
- Summer Squash/Zucchini
- Melons
- Cucumber
- Carrot
- Bush Bean
- Pea
- Sweet Corn
- Beet
- Spinach
- Swiss Chard
- Onions/Leeks
- Rutabaga/Turnip
- Radish
- Salad Greens (Please specify)
- Other (Please specify)

Second, for each crop identified, respondents were asked to select the following:
- Up to three of the most important traits for improvement/plant breeding, from a list of common variety attributes (see list in Table 3). For each trait they selected, they were asked to provide more detail on how that trait needed improvement.
- Up to three of their favourite varieties, why they liked those varieties, and whether they could purchase the variety as organic seed.
- Any other comments about the improvement or development of varieties for that crop.

The seven crops most frequently selected as needing plant breeding improvement were tomatoes, peppers, carrots, lettuce, winter squash, onions/leeks, and broccoli/cauliflower. Response rates for most regions were too low for comparison, but results from the two provinces with higher response rates (BC and Ontario) may provide a view of regional differences and similarities (Table 4).
Table 4. Regional differences in crop priorities between British Columbia and Ontario

Both provinces had 26 respondents, so percentages are out of 26 respondents in each province. Respondents were asked to select all crops of interest.

<table>
<thead>
<tr>
<th>Crop</th>
<th>British Columbia</th>
<th>Ontario</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomato</td>
<td>42%</td>
<td>42%</td>
</tr>
<tr>
<td>Pepper</td>
<td>19%</td>
<td>38%</td>
</tr>
<tr>
<td>Carrot</td>
<td>19%</td>
<td>35%</td>
</tr>
<tr>
<td>Lettuce</td>
<td>15%</td>
<td>35%</td>
</tr>
<tr>
<td>Onions/Leek</td>
<td>19%</td>
<td>23%</td>
</tr>
<tr>
<td>Winter squash</td>
<td>12%</td>
<td>23%</td>
</tr>
<tr>
<td>Broccoli/ Cauliflower</td>
<td>23%</td>
<td>12%</td>
</tr>
</tbody>
</table>

Table 5 summarizes the key traits identified for improvement in these crops based on the percentage of farmers who selected the trait for that crop. For most crops, we have displayed the top three traits identified for improvement, but in a few cases more or fewer traits are displayed due to ties in the number of responses. The researchers coded the responses to open-ended comment fields by theme to summarize comments on priority traits. The phrases in parentheses provide more detail on some of the most commonly written phrases from open-ended comments about each trait.

For most crops, farmers identified flavour/eating quality, productivity/yield, earliness, and disease resistance as the most important traits; this corresponded with the overall trait priorities identified by farmers (see Table 3). There were some differences in which traits farmers felt should be prioritized for improvement of specific crops: temperature tolerance as a top priority for lettuce, pest resistance as a priority for winter squash and broccoli/cauliflower, and transport/storage quality as a top priority for onions/leeks.
Table 5. Summary of key traits for improvement identified by Canadian organic/ecological vegetable farmers

<table>
<thead>
<tr>
<th>Crop</th>
<th># of responses</th>
<th>Key traits for improvement in order of preference (open-ended responses)</th>
</tr>
</thead>
</table>
| Tomato               | 26            | 1. Disease Resistance (Late blight, wilt, blossom end rot)  
2. Eating Quality (Tanginess, sweetness, good flavour across sizes/types, flavour in storage, less cracking/splitting)  
3. Earliness (Adaptation to cold/wet climates)                                                                                                                                                  |
| Pepper               | 23            | 1. Productivity/Yield (More peppers per plant, longer fruiting periods, larger fruits, reliable harvest)  
2. Eating Quality (For both sweet and hot types, uniformity of flavour)  
3. Earliness (Short seasons and low zones, need red bells to ripen faster)                                                                                                                                                                       |
| Carrot               | 21            | 1. Eating Quality (Sweetness, crispness, not woody, holding flavour in ground or storage)  
2. Disease Resistance (Rot, fungal disease, storage diseases)  
3. Other (Earliness, long storage, productivity, resistance to carrot rust fly, strong tops)                                                                                                                                                 |
| Lettuce              | 15            | 1. Temperature Tolerance (Tolerance to heat/bolting, frost, and/or drought)  
2. Disease Resistance (Bottom rot, downy mildew, tip burn, leaf spot, fusarium, especially in Salanova varieties)  
3. Flavour (Less bitterness)                                                                                                                                                                                                                      |
| Winter squash        | 13            | 1. Earliness (For cold/northern climates, under 80/100 days, ripening before frost, flowering and set fruit in cool conditions)  
2. Productivity/Yield (More per plant or per vine, takes up space/resources so productivity needed, extended harvest window)  
3. Disease and Pest Resistance (Tie) (Powdery mildew, downy mildew, squash stem and vine borers, cucumber beetles, sowbug, squash bug)                                                                                                   |
| Onions/Leeks         | 13            | 1. Transport/Storage Quality (Storage past December or through winter, staying firm, less bruising, storable sweet onions)  
2. Other (Mold and mildew resistance, holding flavour longer, need for both sweet and pungent flavours, productivity/yield, need for more open-pollinated storage varieties)                                                                                   |
| Broccoli/Cauliflower | 12            | 1. Quality/Uniformity (Colourful, uniform heading, good sized heads, no sign of disease or sunburn, robustness, heat tolerance)  
2. Earliness (More consistent, under 90 days)  
3. Pest resistance (Cabbage moths, grey aphid, cutworms, root maggot)                                                                                                                                                                         |
“What I have found is that shorter season peppers generally produce many less peppers. More good tasting pepper varieties with higher yields and shorter growing season are needed.”
  - Farmer in Ontario

“One of the challenges with peppers and fruit set during hot summer nights, with a warming climate this may become more of an issue. Over the years I have found very few pepper varieties offered for sale by Canadian seed companies, small or large, to be reliable as far as early, reliable fruit set.”
  - Farmer in Ontario

“We have tried growing OP varieties of carrots, but they have not been commercially viable due to flavour and texture.”
  - Farmer in BC

“Need full range [for lettuce]! Bolt tolerance in summer + frost tolerance spring/fall”
  - Farmer in Ontario

“It would be nice to have lettuce longer in the cold of fall and not go bitter so quickly under drought/hot conditions”
  - Farmer in the Prairies

“Short season squash do not have the flavor that longer season squash have….. Crossing and then stabilizing is a must”
  - Farmer in BC

“Storage [of onions] well beyond Christmas is ideal. This depends on the curing ability, which in turn depends on fruit being entirely mature, with narrow necks that will dry promptly.”
  - Farmer in Ontario

**PREFERRED VARIETIES**

We asked farmers to list the most important and dependable varieties for their farm, and to list the reasons they like those varieties. We have shared detailed responses in an external document, “**Farmer Comments on Preferred Varieties**,” as this information may be useful for farmers, gardeners, researchers, and farmer-breeders looking for specific characteristics. Farmers named 413 favourite varieties, and indicated that 51% out of these varieties were available as organic seed (in some cases, farmers did not agree whether a variety was available as organic, but if one farmer indicated that it was, it was considered available as organic). Table 6 highlights the varieties mentioned by three or more farmers, and the top three traits farmers liked most in the varieties they listed (based on coding the open-ended comments farmers made about why they liked varieties).
<table>
<thead>
<tr>
<th>Crop</th>
<th># of responses</th>
<th>Desirable traits in all varieties listed by farmers (in order of preference)</th>
<th>Example varieties (listed by three or more farmers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tomato</td>
<td>26</td>
<td>1. Flavour 2. Productivity 3. Other (Earliness, disease resistance, visual appeal, marketability)</td>
<td>• San Marzano  • Black Cherry  • Sun Gold</td>
</tr>
<tr>
<td>Pepper</td>
<td>23</td>
<td>1. Productivity 2. Flavour 3. Earliness</td>
<td>• Stocky Red Roaster  • Carmen  • Ace  • King of the North  • Lipstick</td>
</tr>
<tr>
<td>Carrot</td>
<td>21</td>
<td>1. Flavour 2. Visual Appeal, Transport/Storage (tie) 3. Other (Quality, earliness, productivity, and growing conditions e.g., ability to grow in clay)</td>
<td>• Bolero  • Napoli  • Yaya</td>
</tr>
<tr>
<td>Lettuce</td>
<td>15</td>
<td>1. Temperature Tolerance, Productivity (tie) 2. Flavour 3. Visual Appeal</td>
<td>• Coastal Star  • Salanova</td>
</tr>
<tr>
<td>Winter squash</td>
<td>13</td>
<td>1. Flavour 2. Productivity 3. Other (Visual appeal, disease resistance, transport/storage quality, upright/space saver)</td>
<td>• Delicata  • Spaghetti  • Sweet Mama  • Buttercup</td>
</tr>
<tr>
<td>Onions/Leeks</td>
<td>13</td>
<td>1. Visual Appeal 2. Transport/Storage Quality 3. Flavour/Eating Quality, Productivity/Yield (tie)</td>
<td>• Copra</td>
</tr>
<tr>
<td>Broccoli/Cauliflower</td>
<td>12</td>
<td>1. Productivity/Yield 2. Visual Appeal 3. Other (Earliness, temperature tolerance, long harvest window, marketability)</td>
<td>• Arcadia  • Belstar</td>
</tr>
</tbody>
</table>

**CONSIDERATIONS FOR ORGANIC/ECOLOGICAL MANAGEMENT**

When asked for other comments or other required traits for improvement, farmers expressed the need to see a greater number of organic varieties and better quality open-pollinated (OP) varieties. These responses are significant because of two reasons: 1) there is a lack of organic seed available for vegetable growers in Canada (Levert, 2014) and 2) the quality of OP varieties on the market needs to be improved (Shelton and Tracy, 2015).
Moreover, OP varieties are often seen as providing more reliable seed access for farmers because they can be more easily reproduced than hybrid seed. For example, farmers in other studies have reported losing access to hybrid varieties because the seed cannot be easily reproduced from on-farm stocks if a seed company cancels production of the hybrid variety (Lyon, 2015). A greater number of high quality OP varieties in the market can increase seed security and access for farmers.

“I’d like local (Canadian) organic seed for this crop [lettuce].”
- Farmer in Ontario

“[need tomatoes bred] to do well under organic management”
- Farmer in BC

“I would like to see better resistance to root maggots and cut worms [for cabbage] as organic methods of control are limited.”
- Farmer in the Prairies

“Powdery and downy mildews are prevalent here and take out cucurbits too early. ... Thus resistance would be good.”
- Farmer in BC

“We have tried growing OP varieties of both broccoli and cauliflower and the results have been consistently poor: uneven maturity, lack of harvestable crop.”
- Farmer in BC

“Cabbage is one crop that grows well here and can produce seed here quite readily, and can be stored through the winter or processed ... However [there] is little probability of producing the hybrids following a crisis. Thus work on developing better open pollinated varieties.”
- Farmer in the Prairies

“Can’t find a good OP corn variety that works with our short DTM (110 Frost-free days)”
- Farmer in Ontario

“It seems customers prefer bell shaped peppers for the most part though there are no suitable OP varieties I have found.”
- Farmer in Atlantic Canada

REGIONAL VEGETABLE BREEDING PRIORITIES

Due to the limited number of responses in some regions, there was not sufficient data to provide crop-specific breeding priorities at a regional level. In addition, farmers provided information on the crops that are a greatest priority for themselves, which means not all respondents provided feedback on the same crops. Despite the limitations of the data, the following regional considerations were noted:

- Tomatoes are a priority for improvement in all regions and common market vegetables such as peppers, carrots, broccoli/cauliflower, onions and leeks were also cited across all regions.
- Peppers were identified as needing improvement by a larger percentage of farmers in the Atlantic region (71%) and in Ontario (39%), compared to BC (23%), possibly due to their shorter growing seasons. For other crops, similar percentages of farmers chose the crop as a priority across all regions.
There were very few noticeable regional differences in the traits for improvement farmers identified for most crops, and it was difficult to interpret any differences seen because of the small numbers of farmers from each region commenting on each specific crop.

Farmers in regions that experience short growing seasons and colder conditions, particularly Atlantic Canada, the Prairies, and areas further north, indicated days to maturity and cold tolerance as priority traits.

In areas with wetter conditions, specifically BC and Atlantic Canada, disease resistance improvements were priorities.

Some farmers were conscious of the effects of climate change and commented on how changes in weather patterns regionally are leading to new trait preferences. For example, farmers connected the possibility of hot summers and drought conditions with a greater demand for drought-resistant varieties.

“Many of the OP bell peppers are poorly adapted to Atlantic Canada and really do not produce much fruit at all.”
– Farmer in Atlantic Canada

“The varieties [of lettuce] are very specific to the “time of season”, local production and climate. A timely crop for best result for local consumption.”
– Farmer in Ontario

“It would be nice to have lettuce longer in the cold of fall and not go bitter so quickly under drought/hot conditions.”
– Farmer in the Prairies

“Good disease resistance [for peppers] is needed for our wet shoulder seasons.”
– Farmer in BC

“Peppers are so difficult to grow to maturity on the west coast. Early maturing is a must but that also requires that they be grown under plastic so they must be able to withstand high humidity.”
– Farmer in BC

“Our summers in the BC Interior are getting hotter, and it’s harder to grow broccoli all season, need heat resistance.”
– Farmer in BC

BREEDING CONSIDERATIONS BASED ON MARKETING VENUES FOR VEGETABLES

Major marketing venues for vegetables were direct sales to customers, including community supported agriculture and farmers’ markets. Minor marketing venues were wholesale venues (e.g. specialty retail, grocery, etc.) and restaurants (Figure 2).
Figure 2. Vegetable marketing channels used by survey respondents

The 46 respondents who sold vegetables commercially were given a list of common marketing venues for vegetables, and asked to indicate whether each option was a major or minor marketing channel.

Farmers indicated that marketing directly through CSAs or farmers’ markets allowed them to focus on taste, uniqueness, or diversity of varieties over other considerations like storage or transport qualities. Those using direct marketing venues reported that customers either responded well to market stands with lots of colours and shapes, or were more open to being educated about new varieties. Farmers marketing through CSAs and farmers markets also indicated that reliable and consistent harvests were important and that smaller sizes of vegetables were also more desirable. A few farmers reported no effect of marketing venue on breeding priorities.

“Our CSA is 150 members so uniform maturity is a must. We also prefer smaller size fruit [because] each item is $3-$5 value. We don’t mind unusual shapes and colours as we have a captive audience.”
– Farmer in BC

“We aim for selection on our table: specifically unique qualities such as color and size. I also choose varieties that enable us to extend the harvest season or that have qualities that help the vegetables store in the winter”
– Farmer in the Prairies

“Since I sell directly to the consumer, I can focus on eating quality over storage / travel quality. Farmers markets though demand vegetables that look nice.”
– Farmer in Ontario

“We like to follow what the restaurant chef likes but we also have strong farmer’s market and CSA channel so it’s not our main priorities. Production and processing characteristics are probably more important than our marketing channels.”
– Farmer in BC
BREEDING CONSIDERATIONS BASED ON MARKETING VENUES FOR VEGETABLE SEED

The majority of farmers who sold vegetable seed commercially used small-packet direct marketing as a major marketing channel, while fewer used bulk wholesale, small-packet wholesale, or bulk direct marketing (Figure 3).

Figure 3. Vegetable seed marketing channels used by survey respondents

The 34 respondents who sold vegetable seed commercially selected from a list of marketing venues for vegetable seed, and indicated whether the selected option was a major or minor marketing channel.

### Number of farmers using different methods for marketing vegetables for commercial sale

<table>
<thead>
<tr>
<th>Method</th>
<th>Major marketing channel for vegetable seed</th>
<th>Minor marketing channel for vegetable seed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmers’ market</td>
<td>15</td>
<td>4</td>
</tr>
<tr>
<td>CSA/Direct sales</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Other wholesale</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
| Restaurants                | 6                                         | **Note:** Due to space constraints, the number of farmers using each method is not shown in the figure. However, the table below provides a breakdown of the numbers.

Some farmers who sold seed through small packets indicated that there was more of an emphasis on unique varieties, such as those with a story or those suited for a specific region. The two farmers who market bulk seed directly responded with different priorities, including consistent germination rates, hardiness, ease of growth, storability, flavour, and size. Though conclusive findings are not possible with this number of respondents, the differing needs and interests of large and small-scale seed growers warrants further consideration in research and development for the sector.

“My main customer base is home gardeners so they aren’t so interested in varieties that are commercially popular.”
- Farmer in BC

Gardeners like anything that says “heirloom,” in my experience. Farmers seem to like different traits, more reliable, uniform, etc. I definitely think that the farmer or direct bulk options have different crop needs than small pack, and small pack wholesale as a result.
- Farmer in Ontario

I focus on varieties for market gardeners that do well in Atlantic Canada.
- Farmer in Atlantic Canada

“It doesn’t affect it much. I grow what the farm will need ... and assume other farmers would like the same varieties. I focus on varieties for commercial farms.”
- Farmer in BC
SUMMARY OF PRIORITY CROPS AND TRAITS FOR IMPROVEMENT

The survey results provide nation-wide insight into the variety development priorities for Canadian organic/ ecological vegetable farmers. Results suggest that while some priority crops, such as tomatoes, are common across all regions, other crops such as peppers, are a higher plant breeding priority for growers in Eastern Canada than Western Canada. Regarding trait priorities, some qualities such as flavour, earliness, yield, and disease resistance were common across crops and regions in Canada. However, the detailed feedback showed that farmers prioritized different traits for each specific crop. Disease resistance was seen as the most important trait for improvement in tomatoes, while productivity was seen as most important for peppers. In addition, general trait priorities must be interpreted in crop-specific ways. For example, temperature tolerance in broccoli affects uniform head and bead size, while in winter squash temperature tolerance impacts fruit set. These results suggest the need for a regional and crop-specific approach to priority setting for future plant breeding and research in the organic/ecological sector.

COMPARISON WITH OTHER SURVEYS

Several previously published reports provide insight into plant breeding priorities for organic agriculture, focused on the United States. The following table lists these resources by author and institution.

<table>
<thead>
<tr>
<th>Title</th>
<th>Authors/Year</th>
<th>Institutions</th>
<th>Geographic Reach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breeding Research and Education Needs Assessment for Organic Vegetable Growers in the Northeast</td>
<td>Hultegren, Gloss, and Mazourek, 2016</td>
<td>Cornell University</td>
<td>Northeast U.S.</td>
</tr>
<tr>
<td>(unpublished)</td>
<td></td>
<td>L’Union des producteurs agricole (UPA)</td>
<td>Quebec</td>
</tr>
<tr>
<td>Seed and Plant Breeding for Wisconsin’s Organic Vegetable Sector: Understanding Farmers’ Needs</td>
<td>Lyon, Silva, Zystro and Bell, 2015</td>
<td>University of Wisconsin-Madison</td>
<td>Wisconsin, U.S.</td>
</tr>
</tbody>
</table>
In the United States, the University of Wisconsin-Madison and the Organic Seed Alliance released a report summarizing the plant breeding needs of growers across the US (Dawson, Healy, and McCluskey 2017). Cornell University and the Organic Seed Alliance, also conducted similar surveys for growers in the Northeast U.S. (Hultegren et al. 2016) and the Pacific Northwest U.S. (Brouwer and Colley, 2016), respectively. In Canada, such information had only been collected at a regional level, by UPA in Quebec in early 2018. Our survey was modelled off of the surveys conducted in the US and informed the survey distributed in Quebec.

The clearest parallel between our survey and the ones conducted by the University of Wisconsin-Madison and the Organic Seed Alliance was the importance of flavour when selecting and improving vegetable varieties. This was the case when farmers were asked about vegetable variety selection generally, as well as when they were asked about crops on an individual basis. The needs assessment also concluded that, “the productivity characteristics of vegetable crops matter slightly less to direct market vegetable growers than the quality characteristics which attract and retain consumer” (Dawson, Healy, and McCluskey 2017, 5). This is in line with responses from farmers in our survey indicating how marketing vegetables through CSAs or farmers’ markets affected breeding priorities. Farmers in Canada also pointed to the value on uniqueness and diversity for these marketing streams, in addition to flavour.

Comparisons between our findings and those from the UPA survey in Quebec were limited due to differences in questions and survey design. However, in the Quebec survey, less than half of respondents listed yield as “very important,” and higher numbers of respondents selected flavour, adaptation to the region and climate, disease resistance, seed quality (germination rate), and availability of certified organic seeds.

There were few noticeable differences between the priority traits for improvement for individual crops between farmers responding to the US versus Canadian surveys, although a greater percentage of farmers in Canada chose lettuce and winter squash as crops needing improvement, and a greater percentage of farmers in Canada listed disease resistance as a priority for improvement in carrots.

**ADDITIONAL RESULTS AND OPEN-ACCESS DATA**

Our results suggest that when looking at which traits farmers felt should be prioritized, it is more appropriate to look at the data on a crop by crop basis. For this reason and to facilitate further use of this information by plant breeders and farmers, survey data has been made available in an open-access format through the UBC Centre for Sustainable Food Systems Dataverse. In addition, tables showing more detailed crop-by-crop analyses that were not included in this report can be accessed in the following documents: “Traits Identified as Plant Breeding Priorities” and “Farmer Comments on Preferred Varieties.”

Farmers’ responses on availability of organic seed reflect farmer perceptions of availability as opposed to actual availability of that variety as organic seed. In some cases, farmers responding about the same variety gave conflicting answers for whether it was available as organic seed. This could be due to farmers going from memory rather than verifying their responses, or it could be that they answered in terms of whether it was available in Canada or in their region. Regardless, differing perceptions of availability of organic seed suggest a need for better information for farmers about organic seed availability in Canada. An important next step in this research would be to check whether favourite varieties are actually available as organic, using the Ecological Seed Finder database in Canada and the AOSCA Organic Seed Finder in the United States.
CONCLUSION AND NEXT STEPS

Canada’s organic/ecological vegetable farming sector is a small, but growing constituency in Canadian agriculture. The variety preferences of growers in this sector can easily be underserved by the market, which only furthers the need for greater investment and research in the development of regionally-adapted organic/ecological vegetable varieties.

The results help to validate anecdotal data that practitioners in the organic/ecological farming sector have been hearing from farmers for years: flavour is an essential attribute, varieties need to have better pest/disease resistance, varieties should be better adapted to organic conditions, and there needs to be a greater number of high quality OP varieties. Plant breeders and seed growers seeking to develop better varieties for the organic/ecological vegetable sector in Canada now have some preliminary data to use to help create new regionally-adapted varieties.

While there is a clear need for further research, this survey has provided a useful template for how to collect this data among farmers in Canada. In future iterations of similar surveys, a greater effort needs to be taken to increase the response rate, so that more robust conclusions can be drawn. Greater participation can also provide more meaningful information for regionally-specific plant breeding needs.

In 2019, The Bauta Family Initiative on Canadian Seed Security in partnership with the University of British Columbia Centre for Sustainable Food Systems will be launching a participatory plant breeding program on vegetables for organic/ecological farmers in Canada. Breeding populations will be generated by plant breeders at Cornell University, University of Wisconsin-Madison, the Organic Seed Alliance, and Canadian farmers and seed growers. The results from this survey have already informed the material that will be generated for the project, and we hope that it continues to advance vegetable plant breeding efforts at all scales across Canada.
ACKNOWLEDGEMENTS

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REFERENCES


