Breeding, Research, and Education Needs Assessment for Organic Vegetable Growers in the Northeast

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Introduction

The goal of this work is to develop a vision for future organic vegetable breeding and the research and outreach necessary to support the continued growth of Northeast organic vegetable production. The objectives include determining:

1) target traits in major vegetable crops that are priorities for breeding and new cultivar introduction for this region,

2) major production issues that transcend growers' differences in scale of production and marketing focus, and

3) gaps in educational outreach of existing research and successful production techniques.

Context: Ten years of organic seed dialogue in the NE

Such a steering event was long overdue in our region. The only organic breeding survey was conducted ten years ago by the Northeast Farming Association of New York (NOFA-NY) of its statewide membership. In 2005, as part of the USDA-funded "Breeding in and for Organic Farms" (NESARE LNE04-204), organic breeding variety roundtables were held in Maine, New York, Vermont and Pennsylvania to assess the breeding, variety, and specific trait needs of organic farms. Small groups of organic farmers, breeders, and seed companies were brought together to share their organic vegetable breeding needs, varietal trait preferences, and other needs related to availability of organic vegetable seed. The roundtables were held to specifically guide breeding as part of the NESARE-funded grant, but this information has also been used extensively to direct additional breeding as part of the USDA-OREI-funded "Organic Seed Partnership" (Award No. 2004-51300-02229), "NOVIC-Northern Organic Vegetable Improvement Cooperative" (Award No. 2009-51300-05585), and "Addressing Critical Pest Management Challenges in Organic Cucurbit Production" (Award No. 2012-51300-20006). The Organic Seed Partnership and its predecessor, the Public Seed Initiative (Agreement No. 2001-52101-11347), were formative events, based in the Northeast, which influenced national models for work in regional seed systems. Some of the first organic public breeding for organic vegetable growers arose from these efforts. Given the sustained importance of this agricultural sector in our region, the great changes it has undergone and progress it has made within the past decade, and our reliance on up-to-date established priorities to guide future work, it was imperative that we update the Northeast organic vegetable community's needs and priorities.

The Organic Seed Alliance (OSA) surveyed growers throughout the US in 2011 and brought together organic stakeholders as part of their "State of Organic Seed Symposium" (Dillon, 2011). This was part of an ongoing project to monitor the status of organic seed systems in the United States. The key finding was that "Organic seed systems are improving but require increased attention and resources."

Organic growers have specific requirements that are not adequately addressed by conventional agricultural research or variety development. They depend on plow-down cover crops, slow release fertilizers, animal manures, and compost for soil and plant fertility. Pests and diseases are managed as a part of a whole-farm systems approach with only a very few allowable organic pesticides with limited effectiveness. With fewer inputs, organic growers rely more on the vegetable varieties they grow to themselves provide superior pest resistance and high nutrient uptake. Organic farmers thus need varieties that are specifically bred and selected to excel in organic farming systems. This breeding and availability of varieties that perform well for organic farms is one important component in the profitability and success of organic vegetable production. For this breeding work to be effective, the current needs of organic vegetable growers must be known.

Ten years ago, growers provided us with long lists of varieties that they could no longer access which they had depended on to provide communities with robust harvests of marketable crops within specific regions. Replacement varieties had reduced yield and lacked qualities their consumers desired

because they were developed to serve markets and priorities of other regions of the US. Growers shared production challenges and specific unmet variety needs that could be addressed through improved crop genetics. Since then, the organic market has continued to grow, with a twelve percent growth from 2014 to 2015 (Greene 2016). With a growing number of organic farmers and a huge diversity in their scale, marketing, and even production techniques, we needed to better determine common needs of organic vegetable growers so that future breeding, research, and outreach can have the largest impact with limited funding. The information from roundtables and surveys ten years ago no longer necessarily represented the needs of current organic growers. Furthermore, from ten years of breeding in organic systems, we better understood the questions we need to ask growers to better determine their specific needs.

Regionally, there has been increased private sector interest and growth in organic seed production with two new companies growing and selling organic seed starting up in the last ten years in New York State alone. The regional seed companies dedicated to organic seed production in Maine and Vermont continue to grow. This expansion has brought a renewed interest in how to best continue to support this market and the food security, economic, and sustainability contributions of this diversified agriculture in the Northeast. This current work supports the renaissance and revitalization of the seed company by determining the gaps that still exist, and providing public research efforts with priorities to which they can align in service of the goal of sustainable agriculture in the Northeast.

Although the target audience of this conference is organic vegetable growers, solutions for organic growers can also help conventional growers to implement more sustainable practices. Reduced pesticide use and lower input practices is a cornerstone of sustainability in agriculture and are embraced by an increasing number of growers. Organic growers rely more on the traits in their vegetable varieties and on cultural practices to overcome production challenges than on chemical pesticides and herbicides. This restriction prioritizes the development of robust genetics and novel approaches. Conventional growers can then utilize the cultural techniques and new resistant varieties developed for organic growers. There are many challenges, like downy mildew in cucurbits, where solutions developed from research in organic systems have widespread relevance in all production systems (Holdsworth, 2014).

Organic growers in the Northeast are testing new approaches in sustainability and serving major population centers with fresh regional produce. Organic growers have reduced reliance on fossil fuel-derived inputs on their farms. Organic growers have already found alternatives to the neonicotinoid insecticides that are implicated in the loss of honeybee pollinators. Their crops are delivered in short supply chains as fresh, nutritious crops to metropolitan and rural areas that add layers to the existing food system, contributing to resilience in food security and offsetting the vulnerabilities imposed by reliance on food sourced at long national or global distances which can be affected by weather events and international relations.

Although the results of past breeding roundtables have been very useful in helping to steer organic breeding projects, organic agriculture has undergone significant changes in the past ten years and information about the specific current production constraints and needs of growers was needed in order to inform all future organic breeding. This current work reevaluates emerging and continuing needs to assure that organic vegetable breeding and seed production are accurately and appropriately addressing the needs of farmers here in the Northeast.

III. Organic Vegetable Breeding Needs Survey

In the spring of 2015, we created and shared a needs assessment survey with vegetable farmers growing organically in the Northeast to identify future breeding priorities for organic vegetable production. We hope that this work will support organic vegetable production in the Northeast.

Using Cornell's in-house survey software (Qualtrics), we created the "Organic Vegetable Breeding Needs Assessment Survey". This public, anonymous survey was activated on February 9th, and closed on

May 1st, 2015. The survey asked respondents to identify crop varieties that they consider critical to their production, target traits in major vegetable crops that they think should be priorities for breeding and new cultivar introduction for the Northeast, and the major biotic constraints with which they contend (see Appendix A). The survey had five sections. For most of the survey questions (except for rating questions), respondents were allowed to provide more than one response.

- **Section 1** asked respondents to provide basic demographic information about themselves and their production practices; this allows us to differentiate the responses of individuals whose farms have been certified organic (and must therefore comply with more stringent production standards), and those who use mixed practices.
- **Section 2** highlighted potential vulnerabilities in the organic seed supply. Respondents listed varieties of crops that they rely on disproportionately – that is, the varieties that would be a significant loss if the seed were no longer provided as organic or untreated seed – and elaborated on the qualities which make those varieties unique.
- **Section 3** asked respondents to identify any crop varieties that they have relied on in the past, but which are no longer available (having been discontinued by the seed company who previously sold them).
- **Section 4** provided respondents the opportunity to suggest improvements on existing crop varieties.
- **Section 5** asked growers to identify major pests affecting their production, to rate the importance of resistance to various biotic constraints, and to rate the importance of various quality traits. Growers were asked to rate the importance of resistance of various crops to biotic stresses. Ratings were from '1 – Resistance is a critical priority' to '5 – This pest/disease is not a problem'. Growers were asked to rate the importance of various seed qualities. Ratings were from '1 – High priority – please focus on this in your breeding!' to '5 – Not important'.

To reach appropriate growers, we created a database of contacts using the 2014 USDA-NOP database of certified-organic growers (downloaded from http://apps.ams.usda.gov/nop/) to find contact information for growers in the Northeast (CT, ME, MA, NH, NJ, NY, PA, RI, VT) who produced vegetables. We then contacted certifying agencies to inquire whether they had more updated contact lists that they could share with us (Supplementary Table S1). We also contacted relevant grower-focused organizations to ask if they could share the survey in any upcoming communication with their members, or through their social media sites (Supplementary Table S1). The goal of this work was to identify breeding needs for organic production, so we also sought to integrate those who use techniques or approaches that directly overlap with the National Organic Program Standard, but who are not organically certified. In order to do this, we searched NOFA chapter lists of growers who had signed the NOFA-NY Farmer's Pledge™, the NOFA/Mass Sustainability Pledge, and the NOFA-CT Farmer's Pledge. We were then able to filter responses by asking respondents to identify whether some or all of their practices are aligned with the National Organic Program (NOP) standard.

On February 9th, we sent an email with a link to the survey to our contacts (n = 1,003), encouraging growers to share their thoughts with us and share the survey link with others who might be interested. We sent two reminder emails before the survey closed on May 1st.

The survey was completed by 210 participants; while 250 surveys were started online, only 210 provided information to at least one of the questions (see Figure 1 for state representation). Of these, 123 (59%) respondents identified their operations as 'Certified Organic', with the remainder of respondents growing according to NOP-standards (but not certified), according to the 'Naturally Grown' standard, or using a combination of conventional and NOP-compliant practices (Figure 2). The results discussed in this report exclude growers who reported cultivating vegetables on less than 1 full acre of land. (See Appendix B for complete survey responses.)

IV. Highlights of survey results

Though the survey was explicitly focused on vegetable production, we received several non-vegetable responses (e.g. grain and perennial fruit crops) to some of the questions; while these responses are a reminder of the crop diversity grown on small organic produce farms, they have been removed from the figures below.

FIGURE 1: RESPONDENTS BY STATE

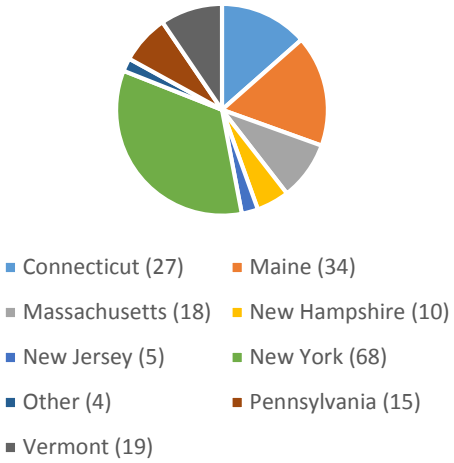
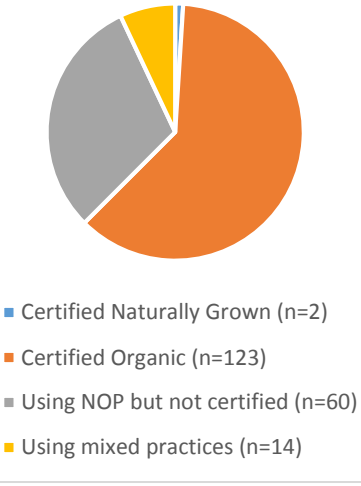


FIGURE 2: TYPE OF MANAGEMENT



Critical Varieties

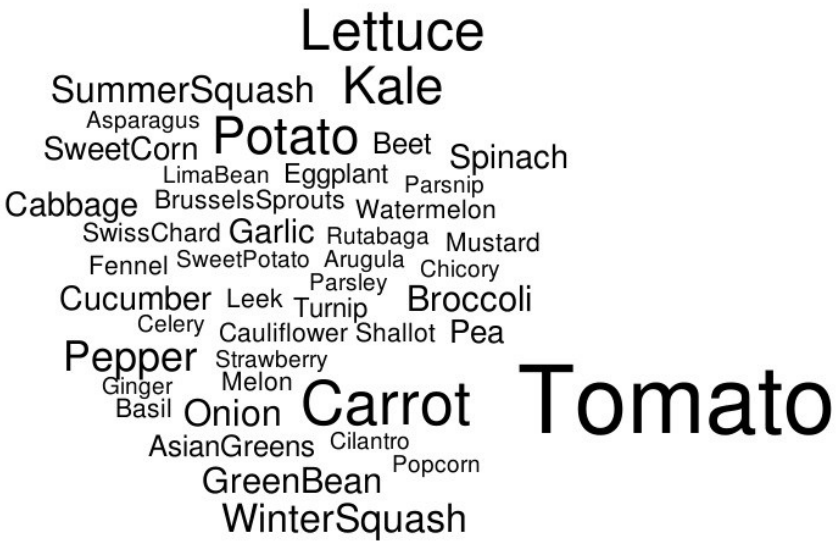
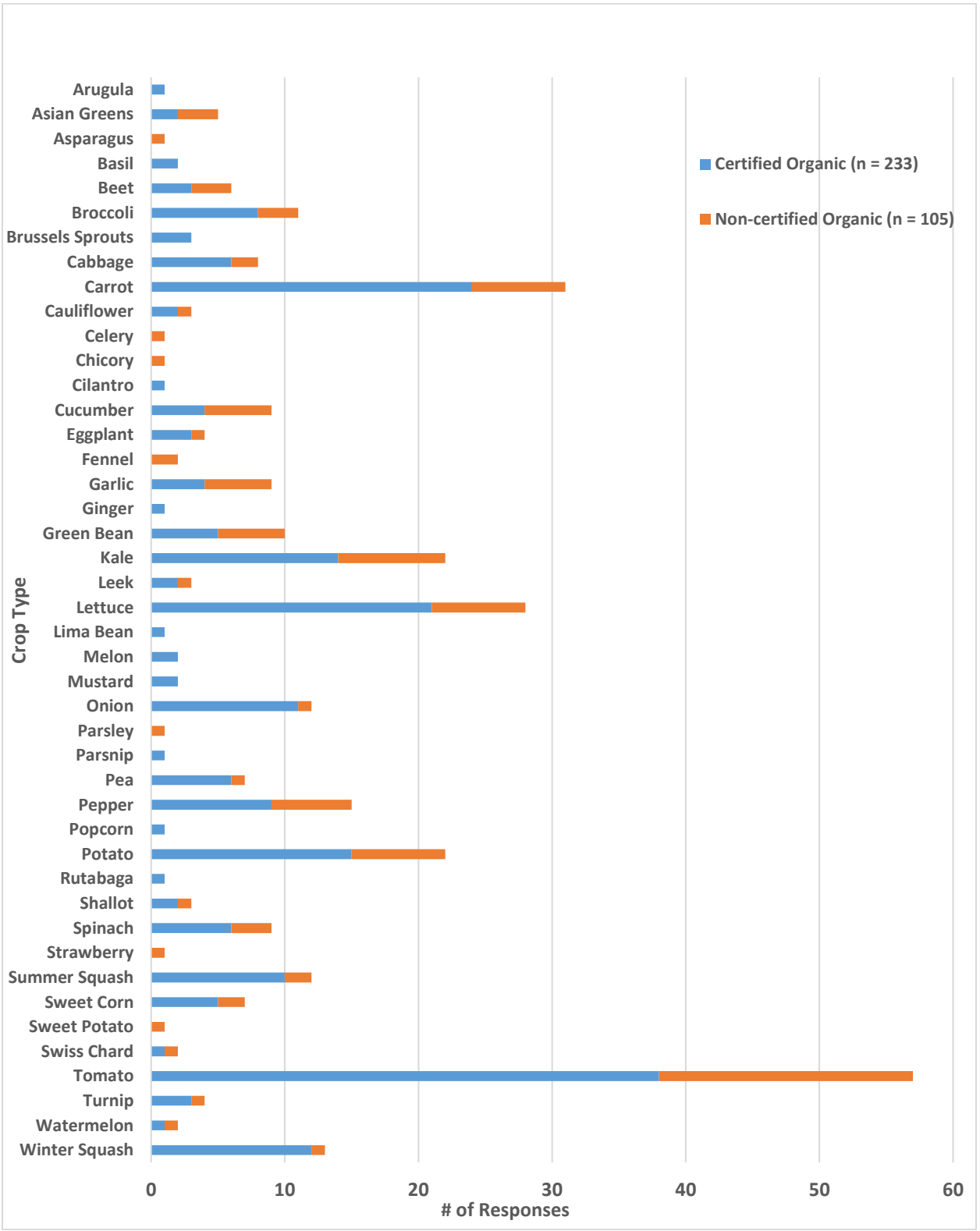


Figure 3: Crop type for critical varieties used in organic vegetable production in the Northeast. Size of words based on number of responses of that crop type received in needs assessment survey (higher count = larger words), not the number of distinct varieties mentioned within a crop.

We received 341 responses identifying critical crop varieties (233 of these identified by certified organic growers) (Figures 3 and 4). These are cultivars upon which growers rely on disproportionately, such that they would find themselves at tremendous loss if the seed were suddenly unavailable in an appropriate, useable form. Growers listed varieties of tomato as being critical to their production more than any other crop; as tomatoes are a high-demand vegetable, this was an unsurprising result.

Figure 4. Response counts for "Section II: Critical Crop Varieties" by crop type. Respondents identified cultivars upon which their production relied on heavily, indicating the crop type, cultivar name, and key attributes of the cultivar.



Though the National Organic Program (NOP) standard requires that certified-organic growers use only organic seed when available, the exemption allows farmers to use non-organic, untreated seeds when an "equivalent organically produced variety is not commercially available". These survey responses make evident the fact that Northeast organic vegetable growers rely heavily upon varieties bred for conventional management. We conducted searches using PickaCarrot.com (a website with a feature to allow growers to locate sources of organically produced seed) to determine whether each variety was commercially available as organic seed. Many of the most heavily represented critical varieties are available only as conventionally produced, untreated seeds (Table 1).

Table 1: Most frequently listed varieties for "Section II: Critical Crop Varieties"

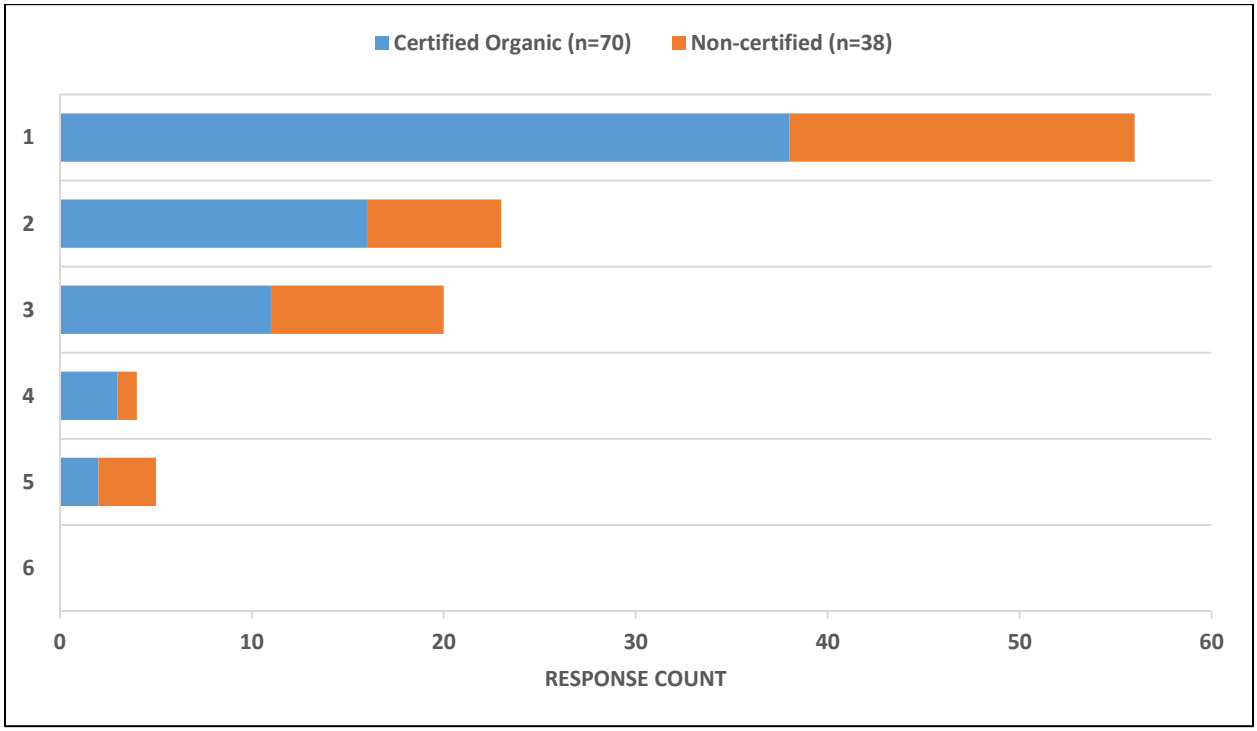
Crop Type	Most frequently listed critical variety (count/total)	Hybrid / OP	Cultivar available as organically-certified seed
Beet	Red Ace (5/6)	F1	Yes
Broccoli	Gypsy (5/11)	F1	No
Cabbage	Storage #4 (4/8)	F1	No
Carrot	Bolero (18/31)	F1	No
Cucumber	Marketmore 76 (3/9)	OP	Yes
Green Bean	Provider (3/10)	OP	Yes
Kale	Winterbor (14/22)	F1	Yes
Lettuce	Various	OP	Yes
Onion	Copra (3/12)	F1	No
Pea	Sugar Snap (5/7)	OP	Yes
Pepper	Carmen (4/15)	F1	Yes
Spinach	Tyee (3/9)	F1	Yes
Summer Squash	Zephyr (3/12)	F1	No
Sweet Corn	Luscious (2/7)	F1	Yes
Tomato	Sungold (15/57)	F1	No
Winter Squash	Delicata (5/13) *	OP	Yes

*Respondents primarily listed 'Delicata', which is a market class, not a specific variety, of winter squash.

Survey respondents rated the availability of variety as organically-certified seed as a high priority (Figure 5), and in their comments, growers noted that they lack appropriate organic options for these crops, and expressed interest in organically produced seed.

Figure 5. Response counts rating the importance of availability of a given cultivar as organically certified seed.

Key for Figure 5
1 - High priority - Please focus on this in your breeding!
3 - Somewhat important
5 - Not important
6 - Unsure



Below are examples of comments made in the survey (all sections of italicized text in this report are direct, unedited quotes from the 'additional comments' section of the survey).

General *"The organic seed requirement is a real quandary-- so many of my favorite and most profitable varieties are not organic."*
Bolero carrots *"I would also like it as an organic option, not just untreated."*
Sungold tomato *"Main variety used for rainbow cherry mix. I keep looking for a good OG substitute."*
"This variety is my single biggest seller. I keep looking for an organic substitute, but have not found it yet."
"Chefs favorite. Cannot get similar in organic that is as good."
Hakurei turnip *"So delicious and tender. We've tried the other salad turnip varieties because we're so uncomfortable with our reliance on Hakurei turnips. But no other variety compares so far."*
Sugar Snap pea *"We love the taste and it has always been a dependable variety for us. Last year we had trouble getting it organically and were not pleased with the alternatives."*
Sunburst summer squash *"This variety seems to show resistance to cucumber beetles compared to green summer squash. Not available organically in organic, and other similar varieties do not produce as well."*

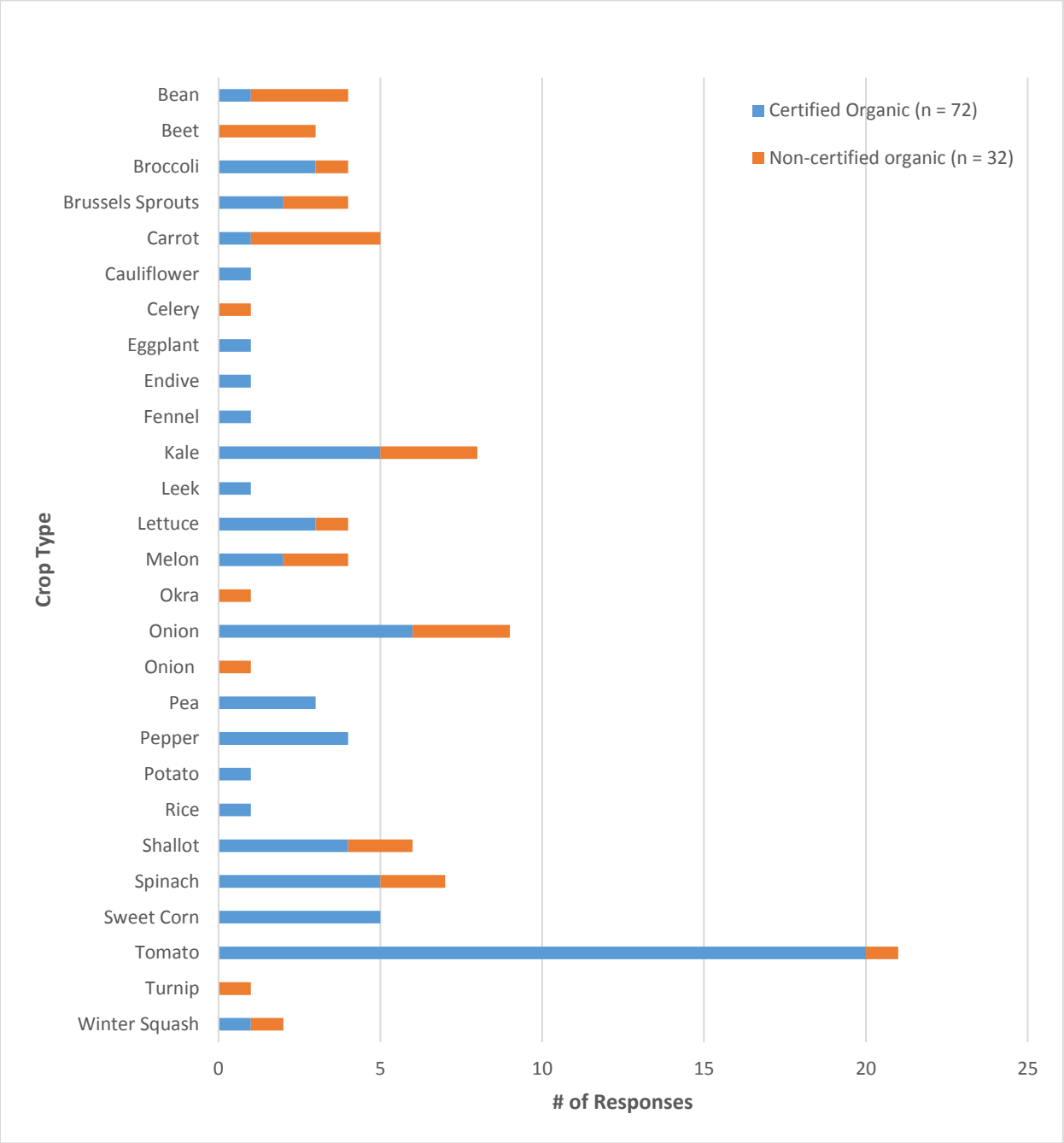
The inability of certified vegetable growers to obtain organic seed for their most important varieties is a handicap to organic production. Conventionally produced seeds are only allowed under the exemption so long as they are available untreated. If the seed companies offering these critical varieties choose to discontinue the lines as untreated seeds, organic vegetable production would suffer without adequate replacements.

Finding organic seed is a major issue. Most of the varieties that wholesale growers use are not available organically, and our certifier says we need 70%+ organic seed. Most of the organic varieties will not produce vegetables that our wholesale buyers will accept.

Lost varieties

Participants provided 106 responses to the question about 'lost' varieties (73 were identified by certified organic growers) (Figure 6). Using the Pick a Carrot search engine, it is clear that some of these varieties have not been discontinued permanently; instead, some that have been dropped from familiar catalogues are still offered by other seed companies. Diversifying the sources from which they obtain seeds can help growers to assure that they can continue to grow their critical varieties. However, expanding their seed search to include all possible sources requires a dedication of time and effort that producers likely do not have. Dependency on a single cultivar or a single source can create vulnerability; the organic vegetable seed production community can help mitigate this dependency by making it easier for growers to find the varieties they want to use, and by assuring that there are appropriate replacement varieties for those being discontinued.

Figure 6. Response counts for "Section III: Critical Crop Varieties that are no longer available" by crop type. Respondents identified cultivars which they were no longer able to purchase, indicating the crop type, cultivar name, key attributes of the cultivar, and the company from which they last purchased the seed.



Varieties to Improve

Participants suggested 198 improvements on existing crop varieties (142 were identified by certified organic growers) (Figure 7). Major themes in the responses included the need for improvement in storability, cold hardiness, and pest & disease resistance, and the importance of quality traits.

The Northeast is a climatically unique region. The ability of a variety to reliably produce regardless of a given year's specific weather is particularly important here in the Northeast. Heat tolerance, cold hardiness and frost tolerance were highlighted as needs in survey responses for broccoli, cabbage, arugula, Swiss chard, onion, kale, leek and lettuce.

The suggested improvements (see Appendix B for respondents' full comments) highlight the role of high tunnel production for organic vegetables in the Northeast. Many of the traits prioritized at the working group meeting indicate that significant production already occurs in covered high tunnels and acknowledge the challenges unique to those growing conditions (see Table 3). The 2015 Vegetable PWT Research and Extension Priority Survey, conducted by Cornell Cooperative Extension's Vegetable Program Work Team, asked fresh market vegetable growers in New York State about their growing practices: 69% of the 187 respondents indicated that they use methods such as high tunnels and row cover for season extension. Northeast farmers rely on high tunnels to ameliorate temperature and damaging weather events (e.g. hail), thereby reducing their risk of crop failure and allowing production into times of the year when conditions would not otherwise be favorable. Priorities such as low light tolerance in arugula and spinach, and overwintering in lettuce would not be of great use to NE growers not already taking advantage of high tunnel production. While high tunnels allow greater control over growing conditions, they also bring challenges, such as the potential for increased disease and insect pest pressure. In a high tunnel, a crop can be in the ground for a longer season, allowing pests and pathogens to build up; additionally, air flow is reduced by the high tunnel itself, encouraging the establishment and growth of pathogens like gray mold on tomatoes, downy mildew on cucurbits, and white mold in beans. Breeding for tolerance to the unique conditions of high tunnels and resistance to pathogens with greater severity in high tunnels is clearly needed to support organic vegetable production in our region.

Storage is another critical component to extending the season and assuring steady income in winter months. As one grower noted, storable varieties are 'important to full year productive sales'. From the responses we received in the survey, storability was evidently a major factor in choosing important varieties of some crops (Figure 8). For example, some growers noted that they value Red Ace and Detroit Dark Red beets because these varieties store well after harvest. Storage and field-holding ability was also consistently mentioned as a reason for importance for cultivars of carrots, cabbage, garlic, kale, leek, onion, potato, and winter squash. Shelf life was noted as important for some varieties of tomato. Growers indicated that cultivars of cabbage, onion, pumpkin, potato, and winter squash (spaghetti squash, buttercup, butternut and delicata type squashes) would benefit from improved storability.

Figure 7. Response counts for "Section IV: New varieties that need to be developed" by crop type. Respondents identified cultivars that could be improved upon, indicating crop type, cultivar name, important current attributes, and suggested improvements.

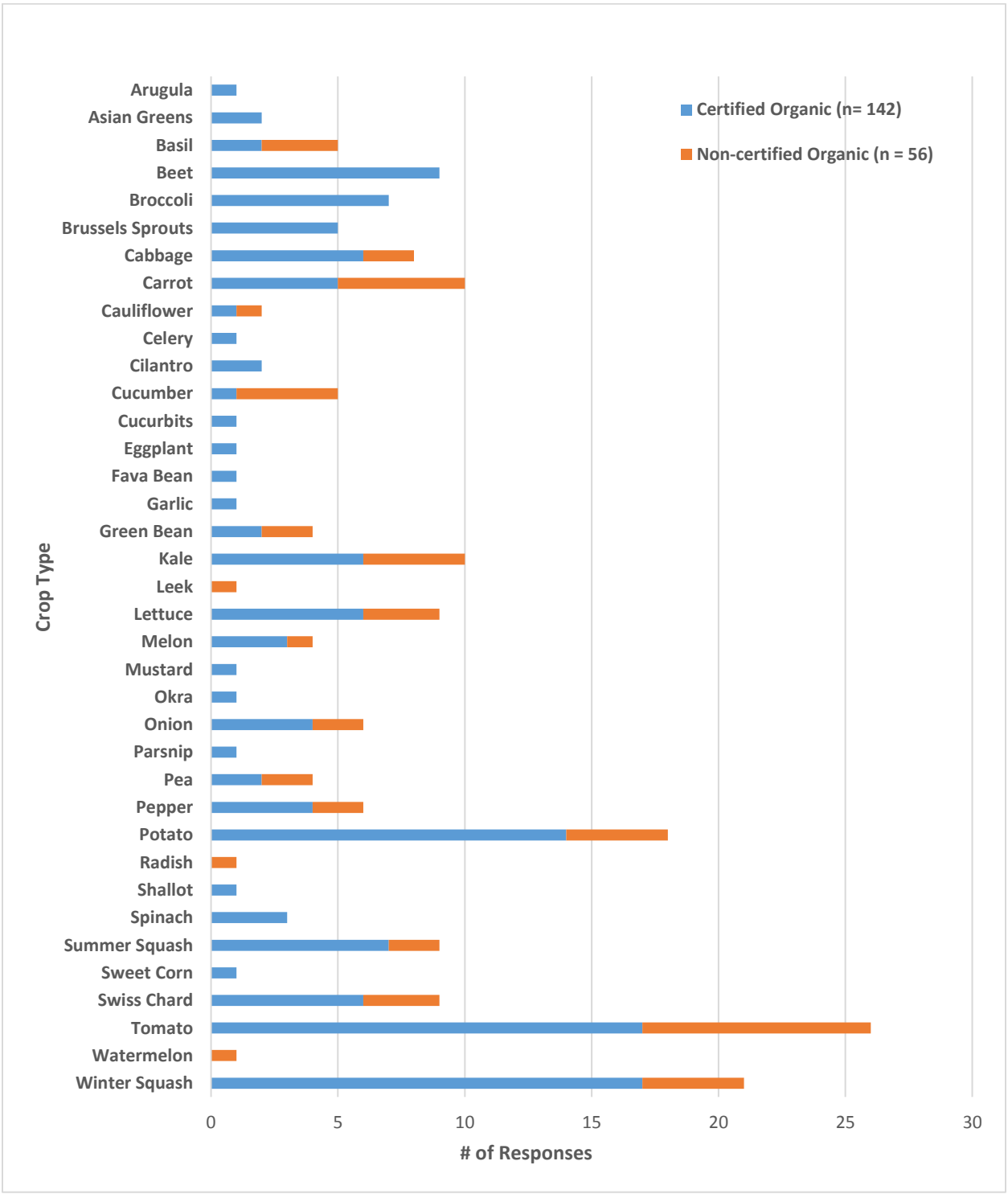
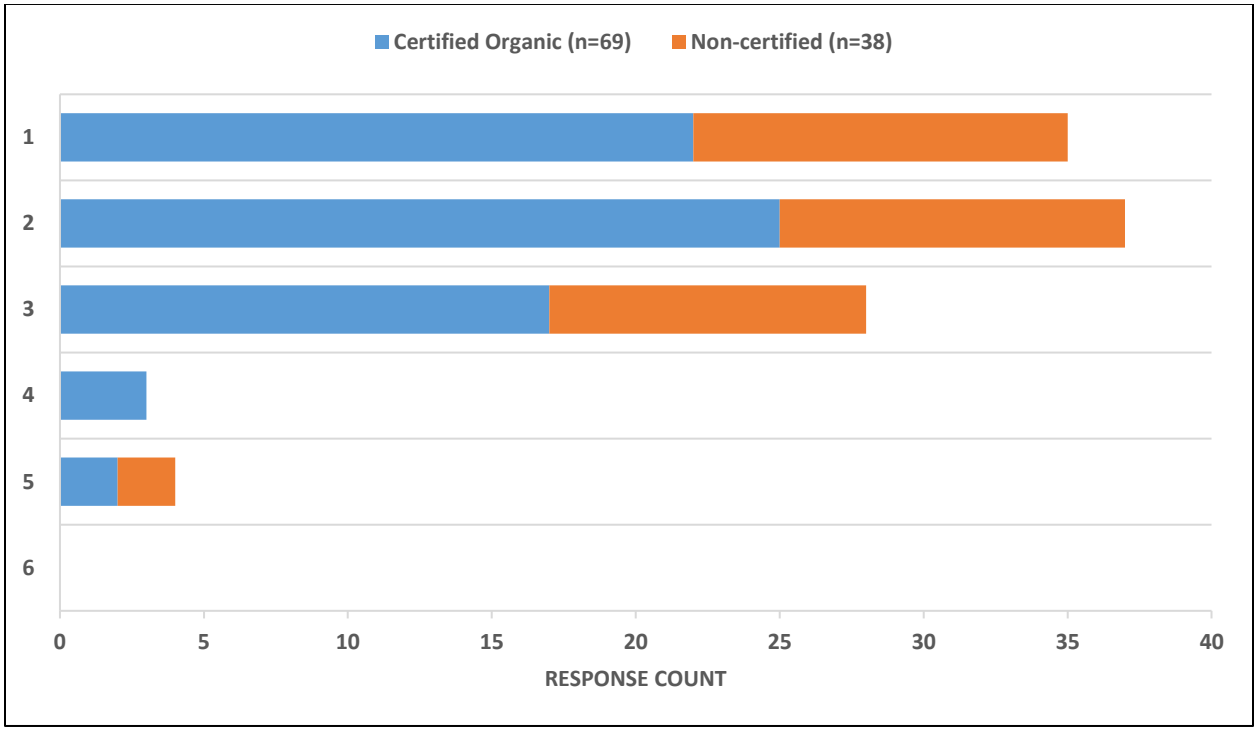


Figure 8. Response counts rating the importance of crop storability as a breeding priority.

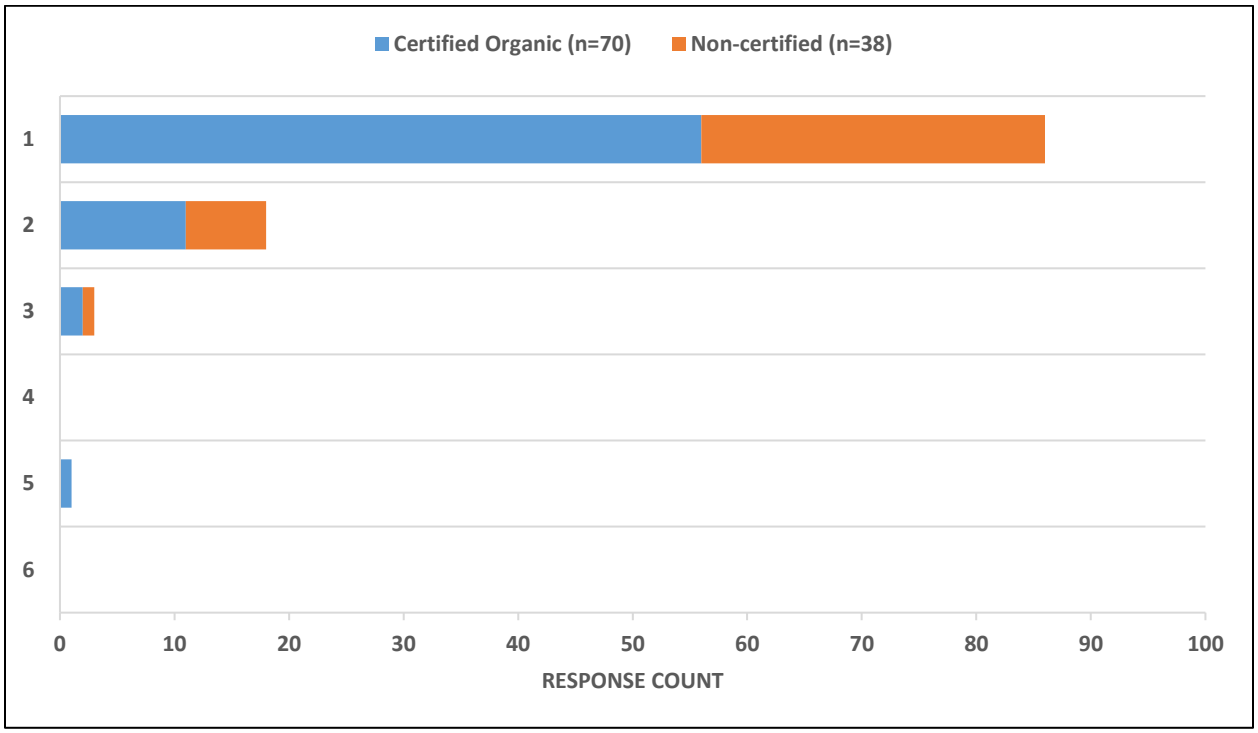
Key for Figure 8
1 - High priority - Please focus on this in your breeding!
3 - Somewhat important
5 - Not important
6 - Unsure



Respondents value quality traits highly – the varieties they depend on are those that appeal to customers with notable appearance and flavor, and the improvements they suggest involve increasing production qualities. When asked to provide the best attributes of the varieties to improve, growers listed primarily quality-related words: sweet, flavor, look, marketability, taste, aroma, delicious, beautiful, color, distinctive, tender, appearance, texture, shape, popular, gorgeous, mild, smooth skin, creamy, attractive, crisp, vibrant, uniformity, consistent marketable shape and size, reliable performer. The vast majority of growers rated flavor as a high priority, indicating that breeding efforts should focus on maintaining or improving quality in addition to agronomic traits. (Figure 9).

Figure 9. Response counts rating the importance of flavor as a breeding priority.

Key for Figure 9
1 - High priority - Please focus on this in your breeding!
3 - Somewhat important
5 - Not important
6 - Unsure



Pests & diseases

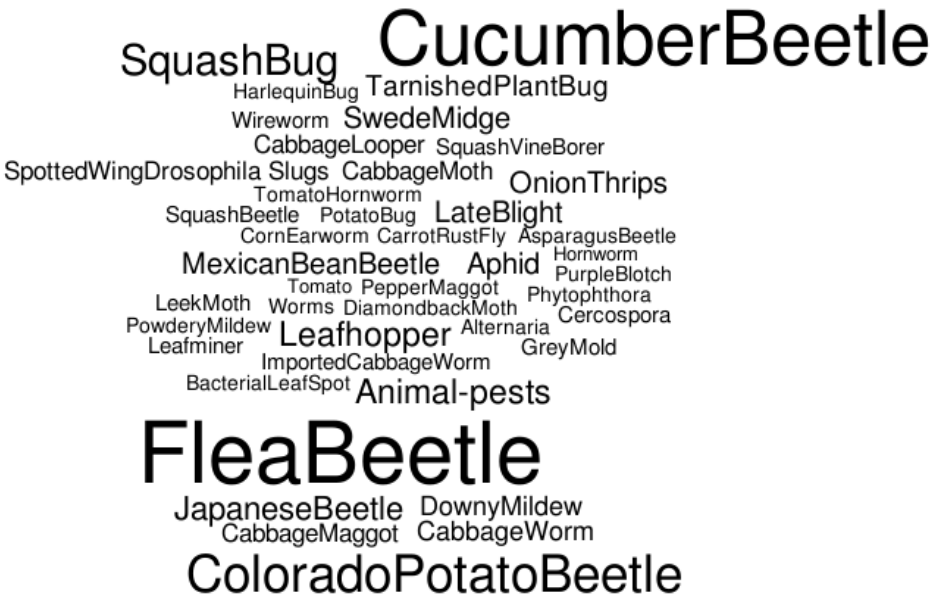


Figure 10: Pest and diseases constraining organic vegetable production in the Northeast. Size of words based on number of responses received in needs assessment survey (higher count = larger words). (Excludes pests that received fewer than 2 responses.)

Growers were asked to identify pest problems that affect their crop production (by reducing yield, quality, and/or marketability) and are difficult to control (e.g. require spraying nearly every year, row covers, and/or other special treatment). While the question asked about pests specifically, respondents identified both pests and pathogens; we received 411 responses identifying pests and diseases constraining vegetable production (272 of these were identified by certified organic growers) (Figures 10, 11, and 12).

It is important to note that while this question asks about pests with significant impact, the responses suggest incidence more than severity; responses indicate the presence and importance of a pest without providing clear quantitative data on the amount or type of damage they inflict. The prominence of 'flea beetle', for example, points to flea beetles being a common problem for organic growers, but not, necessarily, an urgent one.

Some of the pests that respondents identified are continuing needs. For these pests with broad host ranges, there may be quantitative variation that breeders may exploit, however it is unlikely that breeding alone will mitigate their impact, as the germplasm sources of resistance are often still unknown. These constraints will need to be addressed through other efforts. In the case of cucumber beetles, the ability of conventional growers to apply effective pesticides has moved interest away from striped cucumber beetles. For organic growers without such options, the current work of the Mazourek lab to identify and incorporate sources of resistance into appropriate cultivars is an example of focused research efforts being fruitful in this area.

Figures 11 & 12. Response counts for "Section V: Production Challenges" indicating diseases and pests constraining organic vegetable production in the Northeast. Respondents identified pests and diseases that they consider a serious problem for their operation (those that reduce yield, quality, and/or marketability and are difficult to control). Responses were separated by whether the constraint identified was an infectious pathogen (Figure 11) or a non-infectious pest (Figure 12).

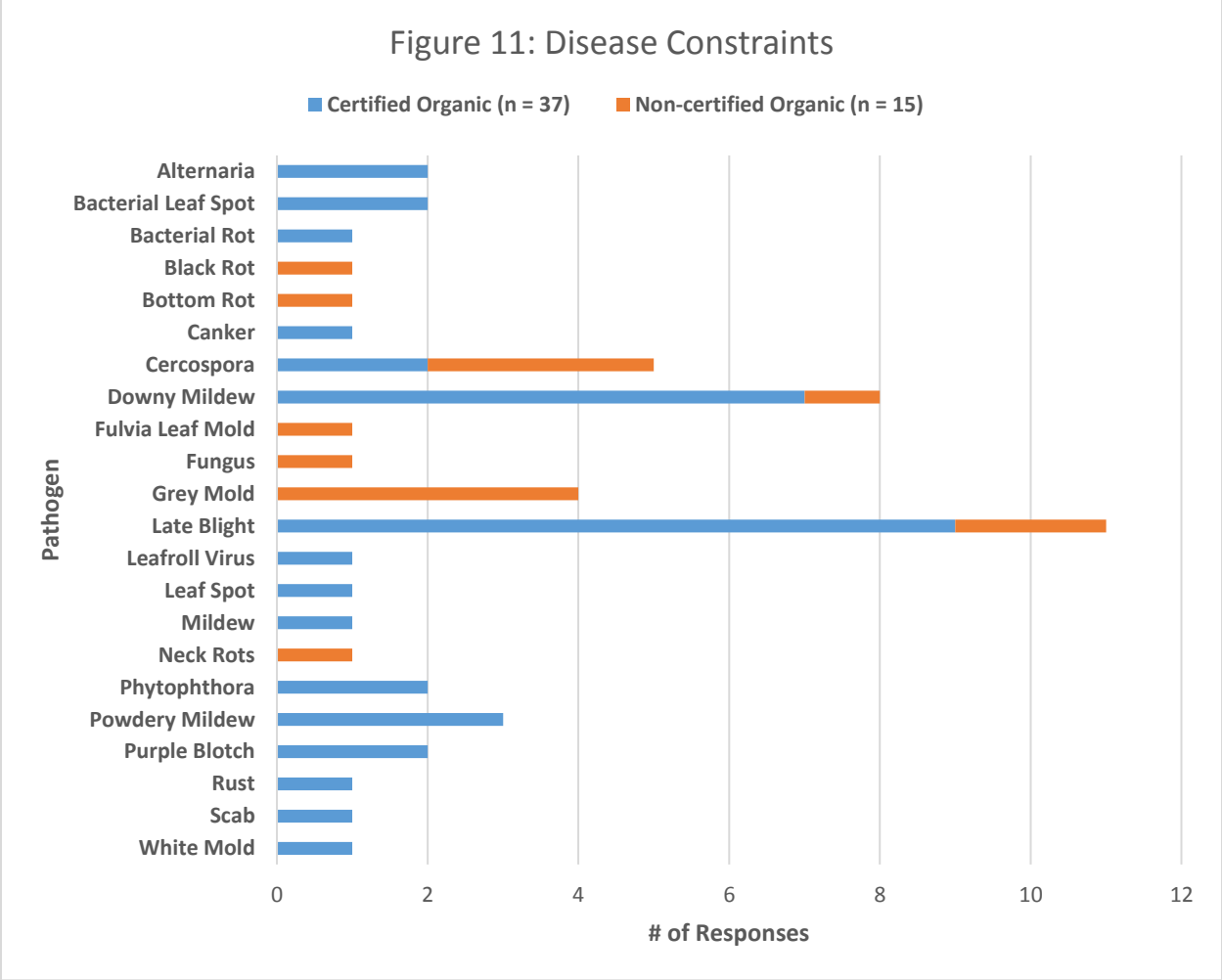
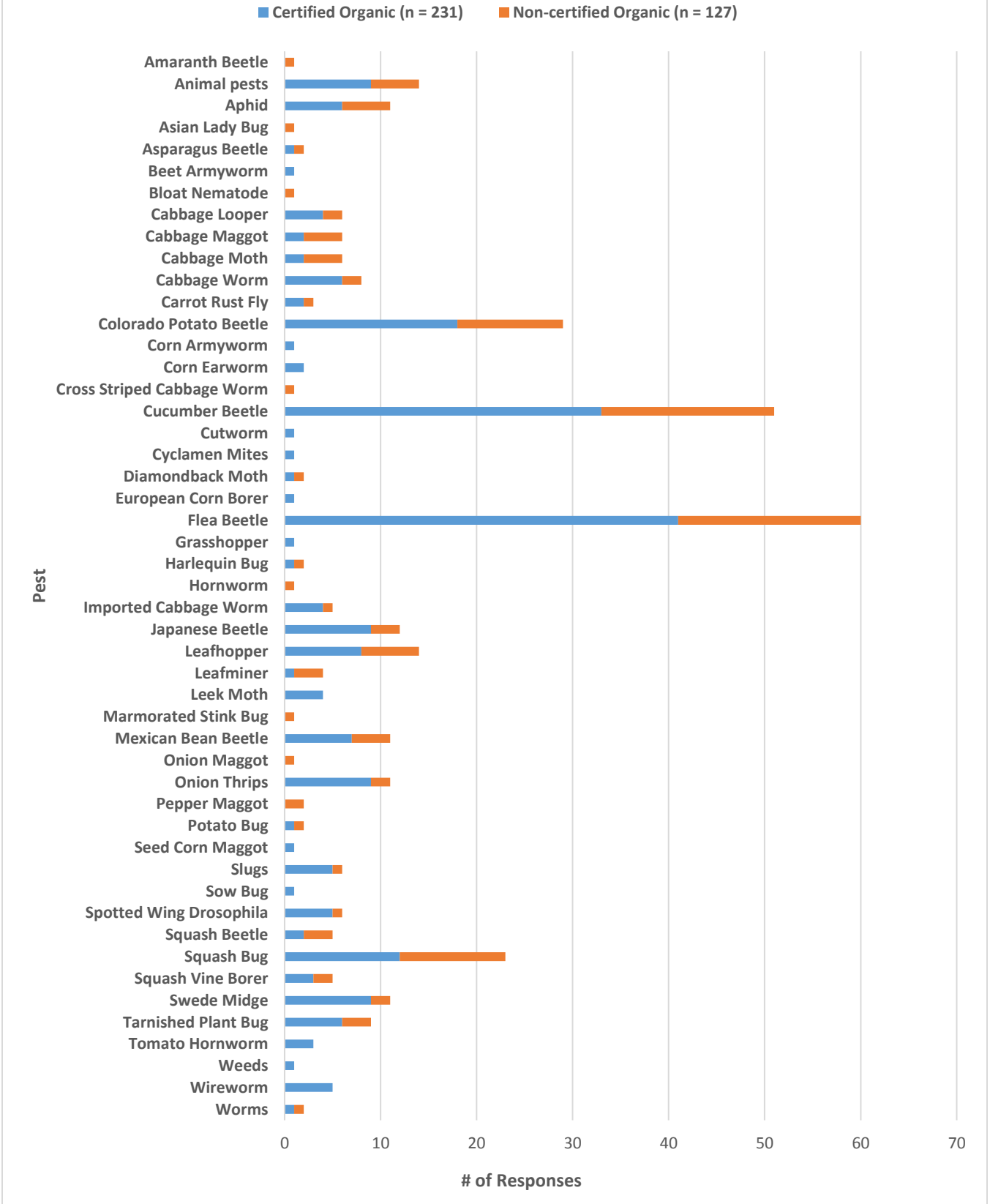


Figure 12: Pest Constraints



While there were 72 distinct pests and diseases identified through the survey, a subset of them appeared more often in the responses (Table 2). It is unclear the extent to which each response represents a correct positive identification of the pest in question; it is possible that the frequency of some is due in part to the ease of their identification. Many different cabbage pests were identified; even if some were misidentified, the responses point to growers having the extension support (in the form of in-person agents or printed/online material) necessary to be able to name the pests specifically. Growers are certainly familiar with many pests, which is encouraging.

Finally, as the Northeast continues to experience changing weather patterns, we can expect conditions to impact the geographical ranges of agricultural pests, leading to greater incidence in some. Knowing the major pest and disease challenges faced by growers will allow breeding efforts to prioritize the resistance traits being incorporated into new cultivars.

Table 2: Most frequently listed pests for "Section V: Production Challenges"

Pest	Crop type most affected	Count of responses (of 411 total)
Flea Beetle	Solanums and Brassicas	60
Cucumber Beetle	Cucurbits	51
Colorado Potato Beetle	Solanums	29
Squash Bug	Cucurbits	23
Leafhopper	Potato	14
Japanese Beetle	Berry crops	12
Aphid	All	11
Late Blight	Tomatoes	11
Mexican Bean Beetle	Bean	11
Onion Thrips	Alliums	11
Swede Midge	Brassicas	11

Rating Resistance Traits

Growers were asked to rate the importance of particular resistance traits, from 'focus on this in your breeding!' to 'this disease/pest is not a problem'. These particular resistance traits are priority areas of focus for the Mazourek lab at Cornell University in order to gauge whether our work in cucurbits and peppers is aligned with grower needs. Of the biotic stresses listed, resistance to downy mildew in cucumber & melons (Figure 13) and striped cucumber beetles in cucurbits (Figure 14) was rated as being of particularly high importance. Powdery mildew resistance in cucumbers, melons or squash was also rated as a critical priority (Figure 15), though such resistance already exists in commercially available cultivars. This rating points to a lack of information for growers and highlights the need to improve the accessibility of cultivar information; it is also possible that powdery mildew resistance is not yet available in grower-preferred cultivars. For organic growers, resistance against bacterial wilt in cucumbers, melons and/or squash (Figure 16), Phytophthora blight in peppers, squash and/or pumpkin (Figure 17), and viruses in all crops (Figure 18) were not as highly prioritized by respondents.

Figures 13-18. Response counts rating the importance of specific resistance traits as breeding priorities.

Key for Figures 13-18

1 - Resistance is a critical priority
3 - Resistance would be helpful
5 - This pest/disease is not a problem
6 - Unsure
7 - I don't grow this crop

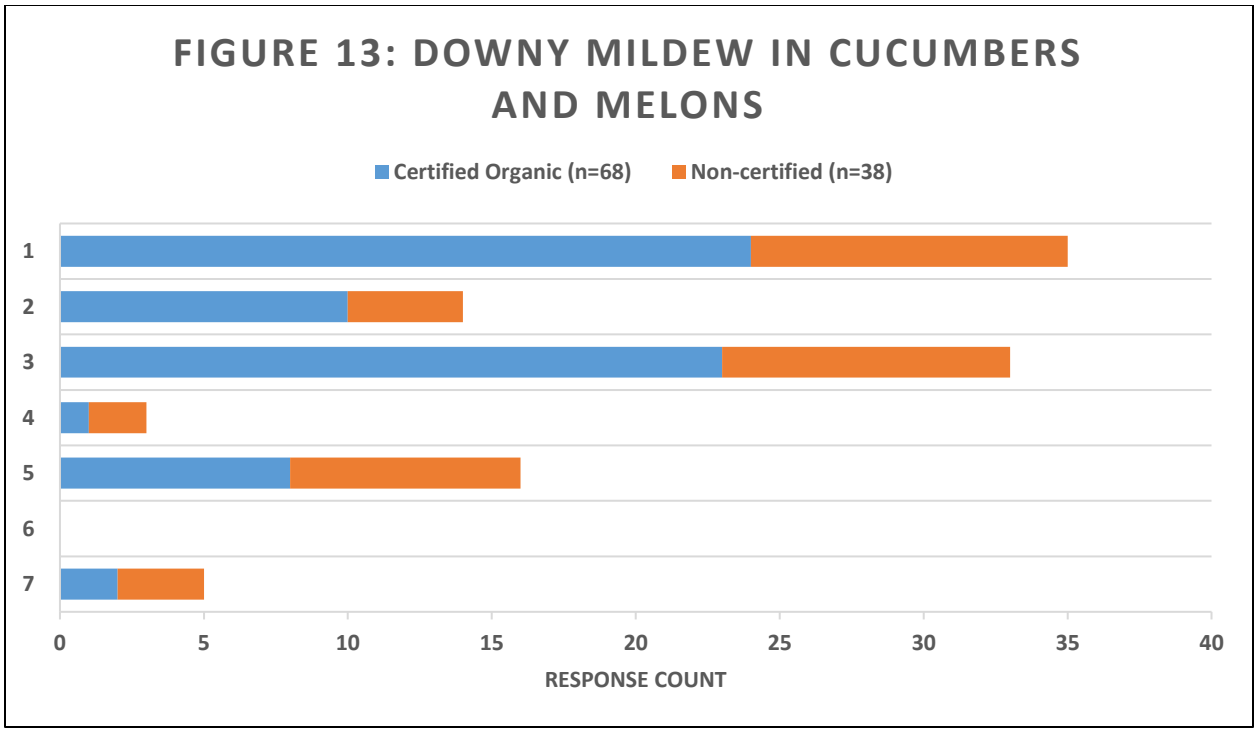


FIGURE 14: STRIPED CUCUMBER BEETLES IN CUCUMBERS, MELONS OR SQUASH

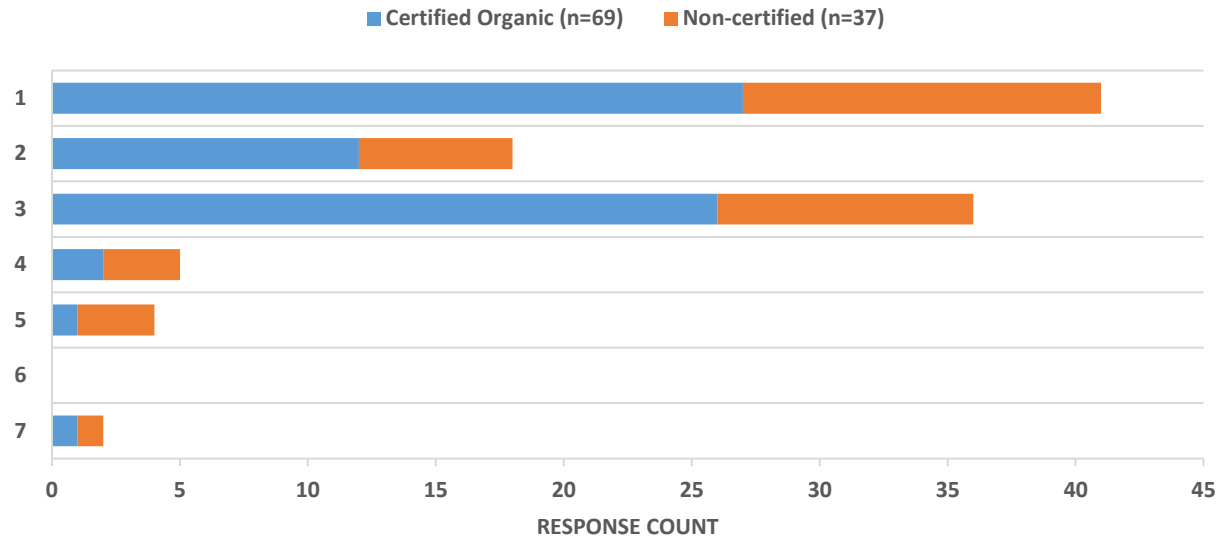


FIGURE 15: POWDERY MILDEW IN CUCUMBERS, MELONS AND/OR SQUASH

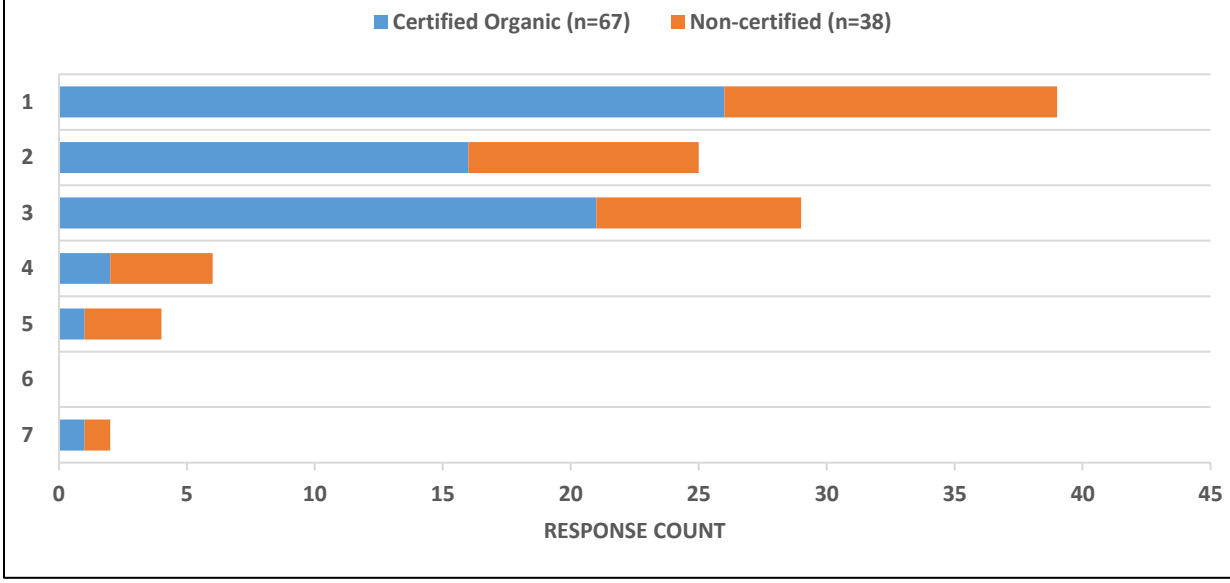


FIGURE 16: BACTERIAL WILT IN CUCUMBERS, MELONS, AND/OR SQUASH

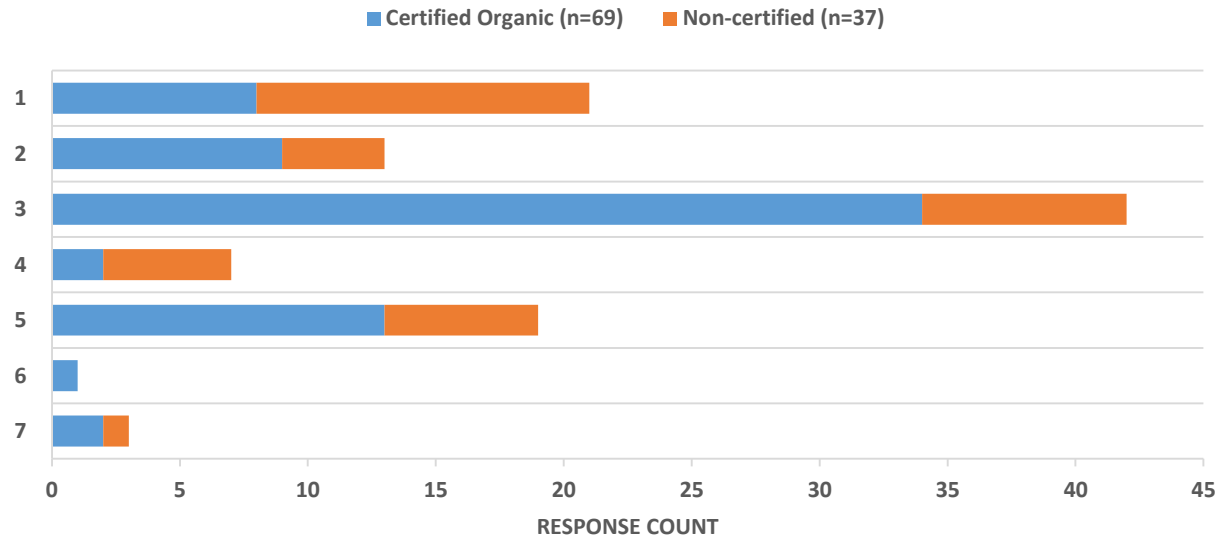
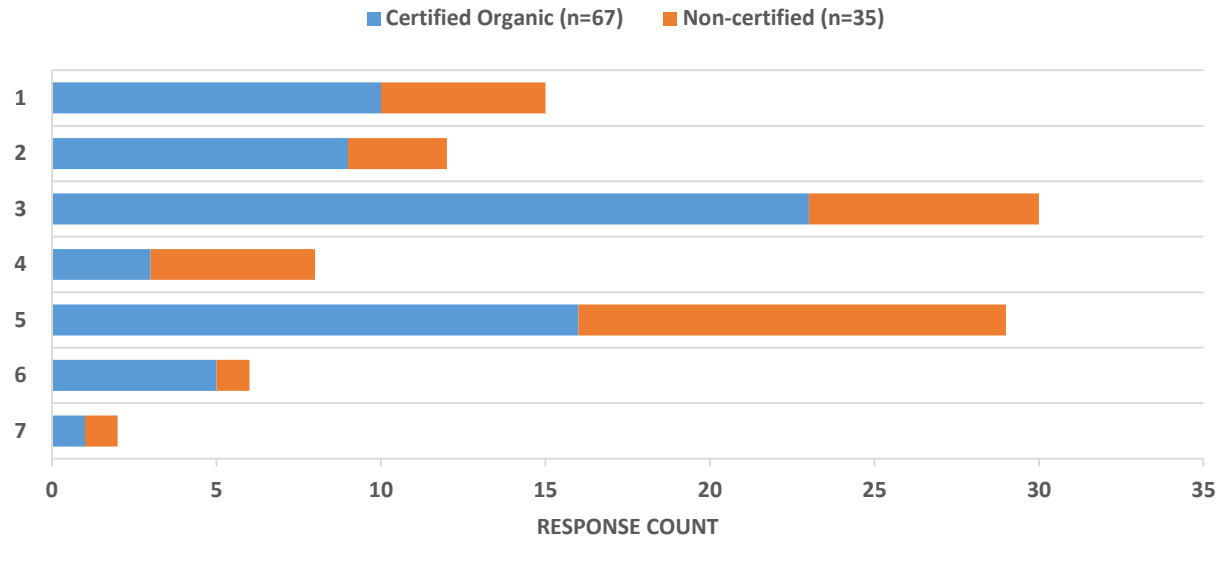
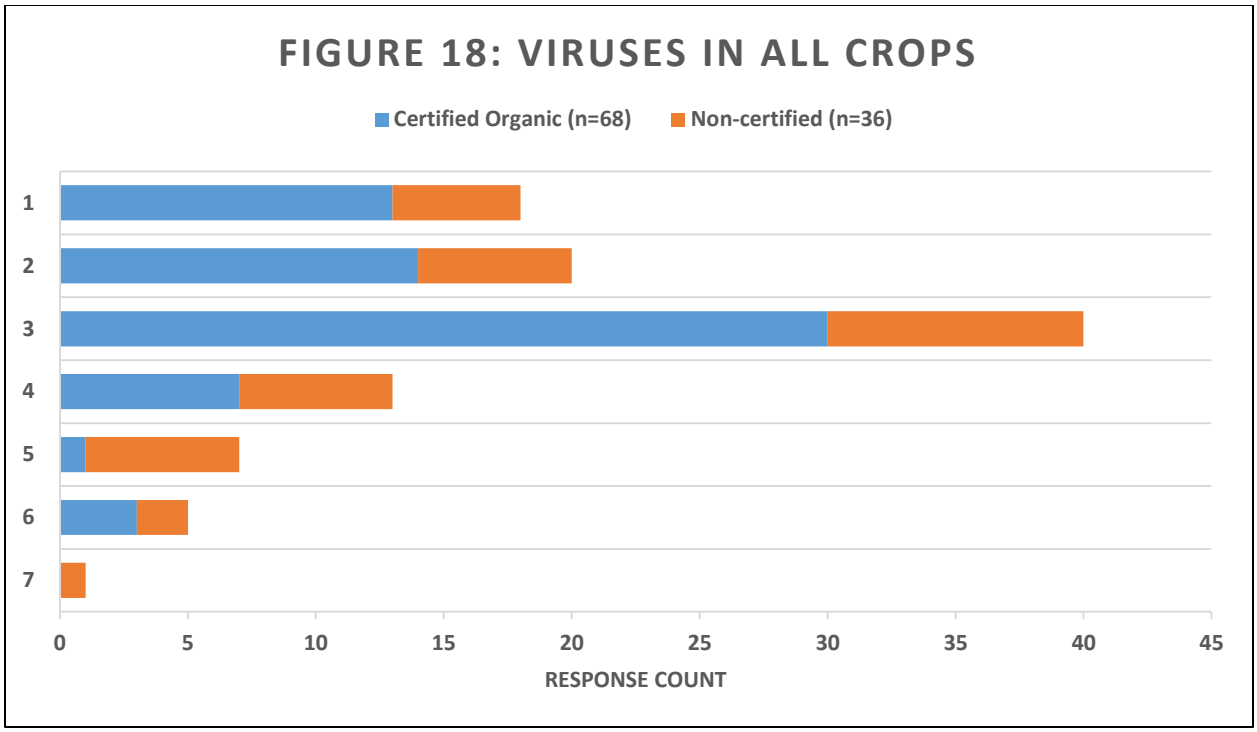


FIGURE 17: PHYTOPHTHORA BLIGHT IN PEPPERS, SQUASH AND/OR PUMPKIN





V. Organic Vegetable Breeding Needs Assessment Working Group meeting

We heard directly from many growers through the survey about the specific crop traits needed to support organic vegetable production in the NE. To facilitate a conversation about the challenges surrounding the delivery of these traits to growers and the actions needed to strengthen the seed production system here in the NE, we held a meeting with representatives of the organic vegetable seed production community.

The Organic Vegetable Breeding Needs Assessment Working Group meeting was held in Saratoga Springs, NY on December 7 & 8, 2015 to discuss themes arising from survey results and to identify opportunities for the seed community. (It was held in eastern NY to facilitate representation from across the Northeast.) The meeting was attended by 26 participants, including organic vegetable growers, representatives of NOFA chapters, cooperative extension agents, public plant breeders, and seed company representatives. The meeting's major outcomes were twofold: prioritization of specific traits needed by organic vegetable growers in the most important 18 vegetable crops (see Table 3), and identification of infrastructural challenges and opportunities around the effective delivery of those traits to growers.

The meeting fostered a connection between Northern and Southern states to increase understanding of how familiar challenges are magnified by warmer weather and without the benefit of very cold winters that reduce pest and pathogen populations. To better learn from other regions, Erin Enouen (a NE farmer and Hudson Valley Seed Library sales and trials manager) attended the Southern Sustainable Agriculture Working Group (SAWG) winter conference to learn how growers in different regions are managing production constraints; she presented at the meeting about her experience. Edmund Frost of Common Wealth Seed Growers in Virginia spoke at the meeting about his on-farm breeding work on disease resistance in cucurbits to bring a perspective from outside the NE.

Table 3: Specific Traits Needs, prioritized by crop at December 2015 Meeting
(Traits with the same number have equal priority; traits prioritized top to bottom with 1 being highest priority)

1	- Broccoli: Stress tolerance
2	- Carrots: Flavor in colored carrots - Winter Squash: Long-term storability
3	- Arugula: heat tolerance - Beans: More east-adapted and/or produced seed - Tomato: Blight resistance - Tomato: resistance to gray mold in greenhouse
4	- Beet: Cercospera resistance
5	- Cabbage: Insect pest resistance (Diamondback moth, cabbage looper, cabbage moth, flea beetles) - Lettuce: Salad mix: reliable weight, packaging quality (color, loft) - Peas: Alternatives to sugar snap cultivars (too few cultivars grown now) - Spinach: Damping off /fusarium resistance - Spinach: Multiple (5+) cuttings - Spinach: Bolting resistance
6	- Broccoli: Black rot / black leg resistance - Cabbage: Processing - Carrots: Alternaria resistance - Cucumbers: Disease resistance - Eggplant: Flavor and education about varieties - Kale: Sweetness in summer - Lettuce: Downy-mildew resistance (research into what races are infecting lettuce in the NE) - Peppers: Strong scaffold / structure
7	- Arugula: Flea beetle resistance - Arugula: Tolerance of low light conditions - Arugula: Succulence / thick leaves - Bean: More organic seed with disease resistance - Bean: Genetics for bean beetle management: earliness, non-preference - Bean: Cool soil emergence - Broccoli: Resilience - Cabbage: Fresh market early red - Cabbage: Storage - Cabbage: Consistent sizing - Carrot: Rust fly resistance - Carrot: Flavor in long-term storage carrot - Cucumber: Climate change (increased heat) tolerance - Eggplant: Earliness / lower temperature adaptation (eggplant for the Northeast!) - Kale: Flea beetle resistance - Lettuce: Bolting / heat tolerance without loss of quality (especially Romaine) - Onion: Thrips resistance - Onion: Downy mildew resistance - Onion: Storability - Onion: Lack of organic sets is a limitation - Peas: Non-trellising types - Radish: Heat tolerance (bolting resistance, maintain spice & texture) - Tomato: Crack resistance (vine holding or consistent growth - Winter Squash: Downy mildew resistance

8	- Arugula: Cold hardiness - Arugula: Aphid resistance - Bean: Higher pod set for mechanical harvest - Bean: White mold resistance - Bean: Concentrated / uniform pod set - Beets: Germination improvement (especially golden beets) - Beets: Improve consistency of Chiogga - Cabbage: Field holding (summer heads that don't split, winter varieties that can handle freezing - Carrot: Strong tops - Cucumber: Understand changing diseases (Phytophthora) - Eggplant: Soil borne diseases (i.e. verticillium) - Eggplant: High tunnel breeding - Eggplant: Insect pests (esp. flea beetle and Colorado Potato Beetle) - Kale: Seed availability (aside from Winterbor) - Kale: Downy mildew resistance - Kale: Longer stems for bunching - Kale: Good shelf life - Lettuce: Less brittle red leafed lettuce - Lettuce: Narrow leaf base (architecture) - Onion: Purple blotch resistance - Onion: Botrytis resistance - Onion: Red onions (improved color) - Onion: Larger / consistent size - Peas: True to type seed - Peas: Foliar disease resistance - Peas: Eating quality (flavor, texture, string-less) - Peas: Longer season / better field holding - Pepper: Early harvest / consistent timing - Pepper: Maintain flavors - Pepper: Cool season production - Pepper: Strong against weeds (reduce need for black plastic) - Pepper: Disease resistance (viral) - Potato: Leaf hopper resistance - Potato: Colorado potato beetle resistance - Potato: Disease/pest-resistant yellow potato - Potato: Scab resistance - Potato: Seed-rot resistant red and blue potatoes - Radish: Uniformity - Radish: Crack resistance - Radish: Crisp texture - Spinach: Overwintering: Tolerance of temperature dips / fluctuations, low light - Spinach: Bacterial spot resistance - Spinach: Aphid resistance - Tomato: Yield - Tomato: Flavor with open architecture - Winter Squash: Striped cucumber beetle resistance - Winter Squash: Gummy stem blight resistance - Winter Squash: Powdery mildew resistance

VI. Working Group Recommendations

In addition to the prioritized list of specific trait needs (Table 3), the working group meeting discussions generated a list of thematic areas where actions are needed to address gaps to meet major production constraints. Among these were the development and production of more regionally adapted, organically produced cultivars, open-pollinated population maintenance, the need for simplified and fairly compensated on-farm variety trials, and the need for education and training opportunities for farmers wanting to produce vegetable seed.

1. Develop and produce more regionally and organically adapted cultivars

Cultivars are most productive under the conditions for which they were bred. This central concept of plant breeding points to the need for Northeast growers to have regionally-adapted varieties that were bred to thrive in the Northeast, with the climate and pests unique to our region. Furthermore, cultivars bred under conventional management – aided by synthetic fertilizer, herbicides and pesticides – will likely not be as productive under organic management. The working group recommended increased research to investigate whether organically bred varieties are better than conventionally bred varieties under organic management.

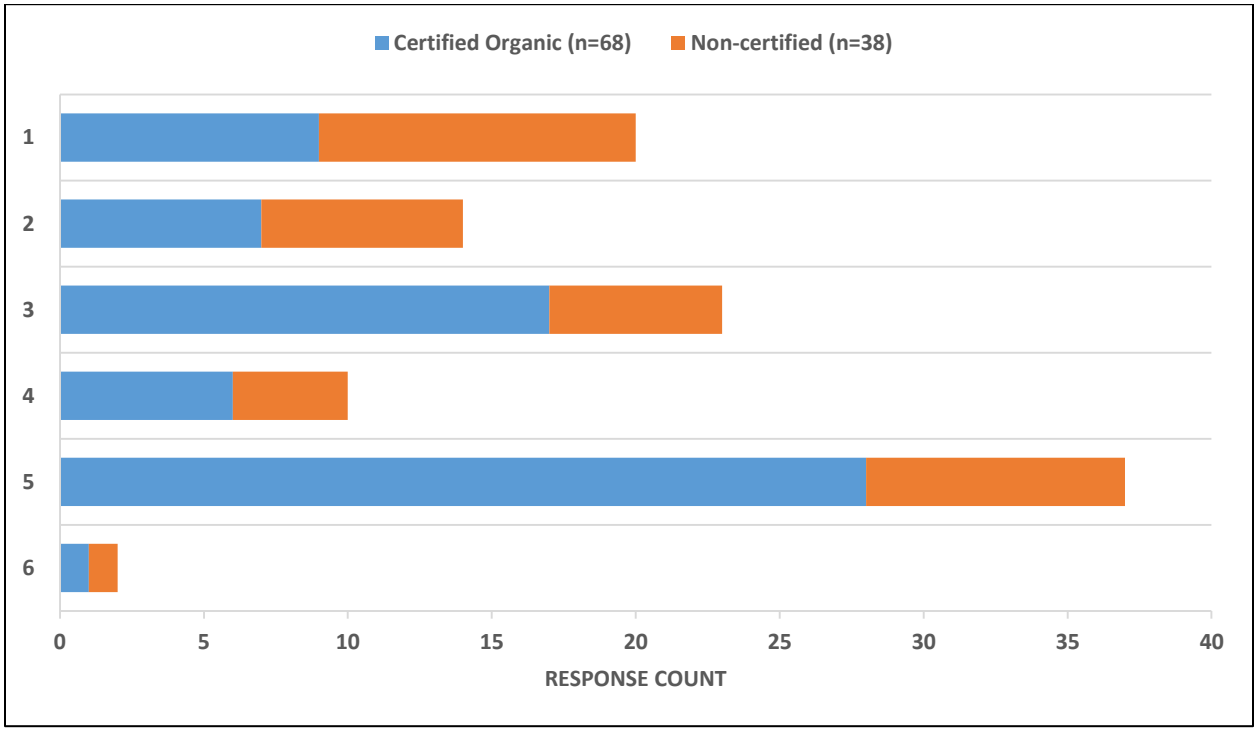
2. Maintain and improve open-pollinated populations

Open-pollinated varieties play a valuable role in strengthening regional food security; the seeds of these cultivars can be saved by farmers and carried by multiple companies, protecting growers from the possibility of losing an important variety. If a hybrid variety is picked up by a company and then discontinued, the resources that were involved in its development are no longer available to the community. It became clear during the working group meeting discussions that not all growers prioritize saving their own seeds, instead appreciating the productivity and uniformity of hybrids when cost-effective. However, the group cautioned against shifting entirely towards hybrids and away from the development and maintenance of open-pollinated cultivars, calling instead for a balanced approach.

The survey results provide insight into the demand for both open-pollinated and hybrid varieties. One notable trend in the critical varieties is the predominance of hybrid cultivars; of varieties listed for the top 15 non-clonal crops were hybrids (Table 1). When asked to rate the importance of a given variety being available as open-pollinated, responses were mixed (Figure 19). It is possible that growers feel that hybrid cultivars are currently secure (despite previous disappearances) because of the investments that have been made in a regional system that will provide continuous support for hybrid production.

Figure 19. Response counts rating the importance of availability of a given cultivar as an open-pollinated variety.

Key for Figure 19
1 - High priority - Please focus on this in your breeding!
3 - Somewhat important
5 - Not important
6 - Unsure



Though the survey did not ask specific clarifying questions about the desire for open-pollinated vs. hybrid varieties, some growers included further thoughts on the topic in the final comments section. The demand for OP cultivars may be attributable to the contribution OP's make to regional food security and their relatively low cost, though it is difficult to say which of these is the primary driver of demand.

"We've relied on many hybrids… that aren't necessarily bred for local conditions and come and go for various reasons. We would much prefer locally adapted open pollinated varieties that have the same attributes, if possible."

"I find more and more crops are hybrids… The seed is so expensive."

Open-pollinated populations must be intentionally and skillfully maintained in order to effectively capitalize on their potential to adapt to local conditions. This maintenance and improvement of existing open-pollinated cultivars will not occur, however, without the intentional action of the seed production community. Education about the importance of the work is needed to engage growers in the work of evaluating and stabilizing open-pollinated strains.

3. Expand and strengthen system for simplified and fairly compensated on-farm variety trials

Another theme in the working group discussions was the need for improved variety trialing and data sharing. As new cultivars are developed, it is critical to evaluate them in the context for which they were bred to determine their relative value under particular conditions. This evaluation is therefore best performed on-farm, where growers can observe the variety within their system. To facilitate grower participation, trials need to be simple in design and fairly compensated. Recordkeeping can be cumbersome when evaluating a crop for multiple quantitative traits; trial coordinators may consider whether more basic, qualitative evaluations would be sufficiently informative to growers and breeding work. Projects ought to allocate sufficient funds to fairly compensate growers for the work of running trials.

There are seed companies developing organically-available cultivars with some of the traits prioritized in Table 3. Organic vegetable growers need information about the performance of these improved varieties to understand how they might appropriately replace older, more familiar cultivars (and be worth the investment such replacement would require). The adoption of newly developed varieties with the specific disease/quality traits desired by Northeast organic growers would be supported by both coordinated evaluation of those varieties, and broad communication of the results of such trials. Word of mouth between growers about successes and failures is helpful, but to allow growers to more broadly learn from one another, it is critical that a system exist that supports the sharing of trial data with similar growers in the region. The Variety Trial Reports site hosted by eOrganic is an example of such a system for organic crops in the US; the extent to which public and private breeding projects use this resource to share their results will determine its utility.

4. Increase education and training opportunities for farmers wanting to produce vegetable seed

Our discussions highlighted the need for improved capacity for seed production in the Northeast. Growers commented on the need for more 'Northeast-adapted cultivars'; regional adaptation requires that seed be produced in the Northeast, and this would be addressed in part by having more seed producers participate in the formal seed sector. As noted in the 2011 State of Organic Seed Report, the flexibility of regional seed companies is an asset to organic production; smaller companies are able to focus on niche markets (like organic producers), and on more specific environmental conditions. The more decentralized seed production in the Northeast becomes, the more regionally self-sustaining it will be. Currently, too few resources exist for farmers wanting to begin to grow and sell vegetable seed. Increased education and training opportunities are needed to support the growth and strengthening of seed production in the Northeast. High quality seed production requires growers to have knowledge in appropriate harvesting, seed processing and seed storage techniques, germination testing, variety maintenance through proper isolation distances, rouging off-types, and disease management, and on-farm breeding strategies to continue to adapt varieties to the Northeast. Seed producers also need to be connected with available land, and with existing companies to learn best practices. We are encouraged by recent discussions to plan the upcoming Northeast Organic Seed Conference to provide for these learning opportunities for interested growers, and recognize that such capacity-building will require long term support for concerted and sustained efforts.

VII. Conclusion

This work addresses recommendations in the “Proceedings of 2014 Summit on Seeds and Breeds for the 21st Century Agriculture” (Tracy, 2014), the purpose of which was to increase the availability and accessibility of regionally adapted cultivars. Among the recommendations made at that summit was that of “identifying on-the-ground regional priorities and challenges to ensure that our solutions meet the needs of stakeholders in each region”. The survey, meeting, and this report have identified such priorities for organic vegetable breeding for the Northeast. The Seeds and Breeds

proceedings suggest that such an identification of priorities would aid in building “public awareness of the importance of public cultivar development” and we hope this is the case.

Additional grower comments from survey

We've relied on many hybrids, especially broccoli, cauliflower, cherry tomato and spinach, that aren't necessarily bred for local conditions and come and go for various reasons. We would much prefer locally adapted open pollinated varieties that have the same attributes, if possible. / Flavor is very important, but can be very localized due to soil and weather conditions. We've grown many varieties, especially of tomato and winter squash that have been described as having excellent flavor by seed companies that don't impress us.

The organic seed requirement is a real quandary-- so many of my favorite and most profitable varieties are not organic (black summer bac choi, Hakurei turnip, graffiti, cheddar, vita verde, Denali, marathon)

This is a long process. It has taken the organic farming movement decades to get where it is today. It is going to take the organic seed movement a long time too. In addition, there is the time delay that it takes to create new varieties. So, we have to be patient. Twenty years ago, for organic farmers, I think marketable yield was perhaps the greatest concern in selecting varieties. Now with the upsurge of local foods, flavor is back to being crucial. So, we really need a balance of concerns to many people (flavor, organic seed availability, open-pollinated seed availability) with commercial concerns (yield, disease resistance). They both have to be met. It is not an either/or situation. If we don't survive commercially, they we have failed. If we don't stay true to our values, then we have failed. We need both. Thank you for your work!

Please focus on maintaining adaptability to weather, climate, and seasonal conditions. I find the OPs are especially reliable in our every changing weather and climate patterns

Finding organic seed is a major issue. Most of the varieties that wholesale growers use are not available organically, and our certifier says we need 70%+ organic seed. Most of the organic varieties will not produce vegetables that our wholesale buyers will accept. We have found only a few lettuce and squash ones.

I find more and more crops are hybrids (carrots, fennel, spinach, broccoli...) The seed is so expensive.

I would also like to see broader farmer collaboration in breeding and seed production in the region.

We need to have options that allow us to be resilient in the face of more volatile weather. I need to have varieties that grow and mature fast. / I am so grateful for this survey - finally a survey that's really worth the time to fill out. Thank you!!

Overall, organic growers in our area are in need of varieties bred for growing without conventional fungicides in humid, cooler Northeastern conditions. Early maturation without sacrificing storability would be great in crops like onions and winter squash, though I understand those two desires are often at cross purposes.
We need more organically certified varieties for storage carrots, & brassicas (mainly cauliflower [especially the colored ones, like Graffiti], & Brussels' Sprouts)

Breeding vegetables that can survive--even thrive--despite climate change seems like a huge priority. We have experienced inconsistent rainfall, snowfall, and unseasonable high and low temperatures since we started farming in our current location in 2010 and some varieties (even within certain crops) obviously do much better in the face of those challenges.

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Supplementary Table S1: Certifying agencies contacted with request for updated lists of certified growers, and farmer organizations contacted with request to share survey with their members

Organization	Type
A Bee Organic	Certifier
Baystate Organic Certifiers	Certifier
CCOF Certification Services, LLC	Certifier
Ecocert ICO, LLC	Certifier
GOA - Global Organic Alliance, Inc.	Certifier
International Certification Services, Inc.	Certifier
MOFGA Certification Services	Certifier
MOSA - Midwest Organic Services Association, Inc.	Certifier
New Hampshire Department Of Agriculture, Division Of Regulatory Services	Certifier
New Jersey Department Of Agriculture	Certifier
NOFA New York, LLC	Certifier
OCIA - Organic Crop Improvement Association	Certifier
OEFFA - Ohio Ecological Food and Farm Association	Certifier
Oregon Tilth	Certifier
Organic Certifiers, Inc.	Certifier
PCO - Pennsylvania Certified Organic	Certifier
Pro-Cert Organic Systems Ltd.	Certifier
Quality Assurance International	Certifier
Quality Certification Services	Certifier
Stellar Certification Services	Certifier
Vermont Organic Farmers, LLC	Certifier
NOFA Vermont	Farmers Org
NOFA/RI	Farmers Org
NOFA-NY	Farmers Org
NOFA-NJ	Farmers Org
NOFA-NH	Farmers Org
NOFA-MA	Farmers Org
NOFA-CT	Farmers Org
MOFGA	Farmers Org
PASA	Farmers Org
Cornell Small Farm Programs	Farmers Org
Northeast Beginning Farmer Project Office	Farmers Org

FIGURE S1: SURVEY RESPONDENTS BY ACRES IN VEGETABLES

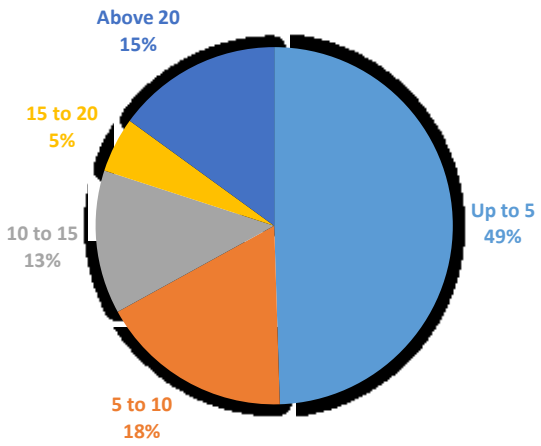
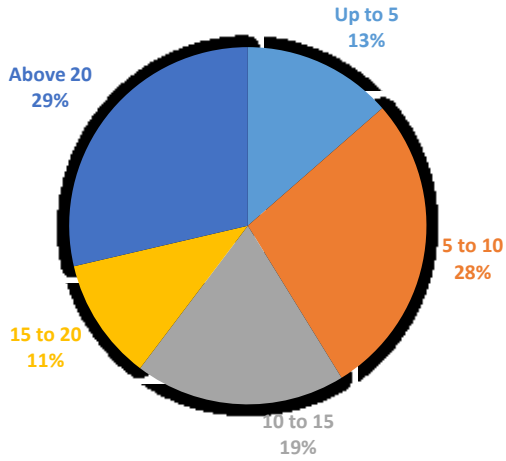


FIGURE S2: SURVEY RESPONDENTS BY YEARS FARMING



Supplemental Table S2: Specific Traits Needs, prioritized by crop at December 2015 Meeting
(Crops have equal priority; traits prioritized within crop, top to bottom)

Peas	- Alternatives to sugar snap cultivars (too few cultivars grown now) - Non-trellising types - True to type seed - Foliar disease resistance - Eating quality (flavor, texture, string-less) - Longer season / better field holding
Eggplant	- Flavor and education about varieties - Earliness / lower temperature adaptation (eggplant for the Northeast!) - Soil borne diseases (i.e. verticillium) - High tunnel breeding - Insect pests (especially flea beetle and Colorado Potato Beetle)
Cabbage	- Insect pest resistance (Diamondback moth, cabbage looper, cabbage moth, flea beetles) - Processing - Fresh market early red - Storage - Consistent sizing - Field holding (summer heads that don't split, winter varieties that can handle freezing)
Spinach	- Damping off /fusarium resistance - Multiple (5+) cuttings - Bolting resistance - Overwintering: Tolerance of temperature dips / fluctuations, low light - Bacterial spot resistance - Aphid resistance
Tomatoes	- Blight resistance - Resistance to gray mold in greenhouse

	- Crack resistance (vine holding or consistent growth) - Flavor and open architecture - Yield
Arugula	- Heat tolerance - Flea beetle resistance - Low light conditions - Succulence / thick leaves - Cold hardiness - Aphid resistance
Kale	- Sweetness in summer - Flea beetle resistance - Seed availability (aside from Winterbor) - Downy mildew - Longer stems for bunching - Good shelf life
Winter Squash	- Long-term storability - Downy mildew resistance - Striped cucumber beetle resistance - Gummy stem blight resistance - Powdery mildew resistance
Potatoes	- Leaf hopper resistance - Colorado potato beetle resistance - Disease/pest-resistant yellow potato - Scab resistance - Seed-rot resistant red and blue potatoes
Lettuce	- Salad mix: reliable weight, packaging quality (color, loft) - Downy-mildew resistance (research into what races are infecting lettuce in the NE) - Bolting / heat tolerance without loss of quality (especially Romaine) - Less brittle red leafed lettuce - Narrow leaf base (architecture)
Beets	- Cercospera resistance - Germination improvement (especially golden beets) - Improve consistency of Chiogga
Cucumbers	- Disease resistance - Climate change (increased heat) tolerance - Changing diseases (Phytophthora)
Peppers	- Strong scaffold / structure - Early harvest / consistent timing - Maintain flavors - Cool season production - Strong against weeds (reduce need for black plastic) - Disease resistance (viral)
Carrots	- Flavor in colored carrots - Alternaria resistance - Rust fly resistance - Flavor in long-term storage carrot

	- Strong tops
Radish	- Heat tolerance (bolting resistance, maintain spice & texture) - Uniformity - Crack resistance - Crisp texture
Bean	- More east-adapted and/or produced seed - More organic seed with disease resistance - Genetics for bean beetle management: earliness, non-preference - Cool soil emergence - Higher pod set for mechanical harvest - White mold resistance - Concentrated / uniform pod set
Broccoli	- Stress tolerance - Black rot / black leg resistance - Resilience
Onion	- Thrips resistance - Downy mildew resistance - Storability - Lack of organic sets is a limitation - Purple blotch resistance - Botrytis resistance - Red onions (improved color) - Larger / consistent size