

Organic Vegetable Trials and Plant Breeding Needs Assessment and Strategy for National Collaboration



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Summary

Crop varieties well suited to regional organic farm environments are an important component of a sustainable food system. It is well established that conventional breeding priorities can differ from organic breeding priorities, and that breeding for organic systems is critical to developing high-performing varieties for organic agriculture. There is growing interest among plant breeders, especially at public universities and small to medium sized seed companies, in performing selection within organic production systems, and prioritizing traits important to organic farmers. There has been little coordination among these efforts, however, and little opportunity for stakeholders committed to organic breeding to strategize about the direction this movement should take.

In 2016 Julie Dawson at University of Wisconsin, Madison, Jim Myers at Oregon State University and Micaela Colley at Organic Seed Alliance wrote a grant to do an organic vegetable grower survey and a series of interviews with plant breeders and seed companies to better understand gaps in organic cultivar development, breeding priorities for important crops and stakeholders' visions for how a national trialing network could function. Responses to the surveys and interviews were compared to findings from previous meetings on similar topics held in the Pacific Northwest, Northeast, and Upper Midwest, to yield a more nuanced understanding of gaps in organic plant breeding and potential for multi-regional collaboration in the future.

The Organic Variety Trialing and Breeding Strategy Summit, held in Madison, WI, on February 22, 2017, brought together plant breeders, seed company representatives and organic seed advocates from around the country to discuss possibilities for synergizing efforts to increase the number of high quality organic cultivars, and the amount of organic seed of those cultivars, available to organic farmers. From these outreach efforts emerged a vision for a national trialing and education network, as well as a body of important questions to consider while moving forward with this work.

The intent of this report is to summarize the survey and interview findings, and collate them with the findings of regional work focused on the Northeast, Midwest and Pacific Northwest. This report also summarizes the discussion from the summit, including suggested next steps for the organic vegetable breeding community.

Background: The need for an organic variety trialing network

The market for organic produce has grown by double digits annually since the mid 1990s, but the organic seed sector has not kept pace with these trends. In the 2016 State of Organic Seed Report, the Organic Seed Alliance found that 82% of organic vegetable farmers still depend on conventional seed for some portion of their production. Myriad reasons explain this persistent lag in organic seed usage. The high cost of purchasing organic seed deters farmers from choosing organic seed over conventional seed for the varieties they prefer. The additional risk assumed and expense required to grow high quality organic seed, especially organic hybrid seed, prevents seed companies from offering sufficient organic options at a realistic price point for organic farmers. Inconsistent enforcement of the National Organic Program's organic seed rule allows some farmers to rely on conventional varieties rather than experimenting with organic varieties, even when they understand the benefits of investing in the latter (OSA, 2016). A decline in public plant breeding and lack of institutional investment in plant breeding specifically for organic growing environments limits the performance potential of varieties offered as organic seed, further disenchanting farmers and discouraging seed companies from increasing their selection of organic seed (Carter, 2014).

Independent plant breeders and farmer-breeders developing varieties for organic systems often possess unique germplasm featuring important traits for adaptation to challenging organic environments. These breeders, however, often lack the capacity to broadly trial material in heterogeneous environments, and attract the attention of seed companies potentially interested in organic variety commercialization. A national variety trialing network for organic crops would benefit independent breeders, by connecting them to seed companies or other partners, and providing diverse trialing environments. Plant breeders at universities and small to medium-sized seed companies would benefit from a better

understanding of genotype by environment interactions for priority traits in organic vegetables, and how selection in one region can benefit or hinder performance in another region. Farmers would benefit from increased variety information and trialing capacity to help them make the most of every dollar spent on organic. Collaboration and capacity-building among breeders, farmers and seed companies can enable multi-environment trials for vegetable breeding with efficient use of limited resources.

Methods

Organic Growers Survey

The Organic Growers Survey was designed by members of the project team, and was based in part on a successful survey conducted by Lyon et al. in 2012, aimed at accessing organic farmers plant breeding priorities in Wisconsin. The survey was also designed as a supplement to the State of Organic Seed (SOS) survey and report, released in 2016. While the SOS survey targeted farmers’ opinions on organic seed availability, accessibility and quality, it did not elicit responses about priority traits for specific crops.

The survey was designed using survey monkey. An initial draft was sent to small pilot group of 8 organic vegetable farmers around the country. Their feedback was incorporated into a final draft distributed to 279 farmers using the Organic Seed Alliance farmer and seed grower lists, as well as the SOS distribution list. Additional farmers were reached through farmer organizations, such as Midwest Organic and Sustainable Education Services (MOSES), who distributed the survey through their e-mail lists.

Survey responses were compiled automatically and exported into Microsoft Excel spreadsheets. Responses were analyzed and graphs were created using the R package tm (Feinerer, Hornik and Meyer 2008).

Plant Breeder and Seed Company Interviews

27 vegetable breeders and seed company representatives were interviewed about gaps in organic seed availability and cultivar development, barriers to releasing or offering more organic cultivars, and whether/how a national trialing network for organic cultivars would be useful. Staff at UW-Madison, Oregon State University and the Organic Seed Alliance conducted interviews by phone and in-person when possible. Plant breeders were interviewed about plant breeding priorities and specific traits important to organic farmers, with regard to their crop(s) of expertise. Seed company representatives were asked to select three or four crops to discuss, based on where their customers have identified gaps in availability of organic cultivars, or specific traits important to organic farmers. Interview participants were recruited from the known network of university, seed company and independent plant breeders who develop vegetable crops for organic environments, and from the pool of small to medium-sized seed companies who offer organic seed of cultivars bred for organic systems. Interview participants are listed in Table 2. Interview results were compiled in an excel spreadsheet and analyzed qualitatively for common themes.

Table 1. 2016 Interview Participants

Seed Company Representatives		Plant Breeders	
Name	Company	Name	Company
Aaron Whaley	AP Whaley	Beth Rasgorshek	Canyon Bounty
Ada Snyder	High Mowing	Emily Haga	Johnny’s
Adrienne Shelton	Vitalis	Irwin Goldman	UW-Madison
Bill Whitson*	Cultivariable	Jason Cavatorta	Earthworks

Seed Company Representatives		Plant Breeders	
Name	Company	Name	Company
Chris Becker	Osborne	Jodi Lew-Smith	High Mowing
Heron Breen	Fedco	John Hart	Earthworks
Jan van der Heide	Bejo	John Navazio	Johnny's
Ken Greene	Hudson Valley	Jonathan Spero	Lupine Knoll
Paul Betz	High Mowing	Keith Mueller	KC Tomatoes
Pete Zuck	Johnny's	Lindsey Wyatt	Johnny's
Petra Page-Mann*	Fruition	Loretta Sandoval	Zulu's Petals
Steve Peters*	Seed Revolution Now	Michael Mazourek	Cornell
Ellen Leue	PanAmerican Seed	Phil Simon	USDA-ARS, UW-Madison
		Frank Morton*	Wild Garden Seeds

*Participants were asked a combination of seed company and plant breeder questions

Previous Work

In preparation for the Summit, results from two previous publications and a series of previous meetings were compiled with results from the surveys and interviews conducted for this project, to demonstrate regional variation and alignment in plant breeding priorities. Precise methods used in the Pacific Northwest Organic Plant Breeding Assessment of Needs, the Breeding, Research, and Education Needs Assessment for Organic Vegetable Growers in the Northeast, and the Seed to Kitchen annual Midwestern farmer meetings, vary from those used in the 2016 grower survey and interviews. Because our methodology was different, we did not attempt to compile responses for uniform analysis. Rather, we compiled findings from these studies into a single table to provide a snapshot of plant breeding priorities and seed system gaps nation-wide. Detailed information on these projects' distinct methods can be found in the respective publications.

Results

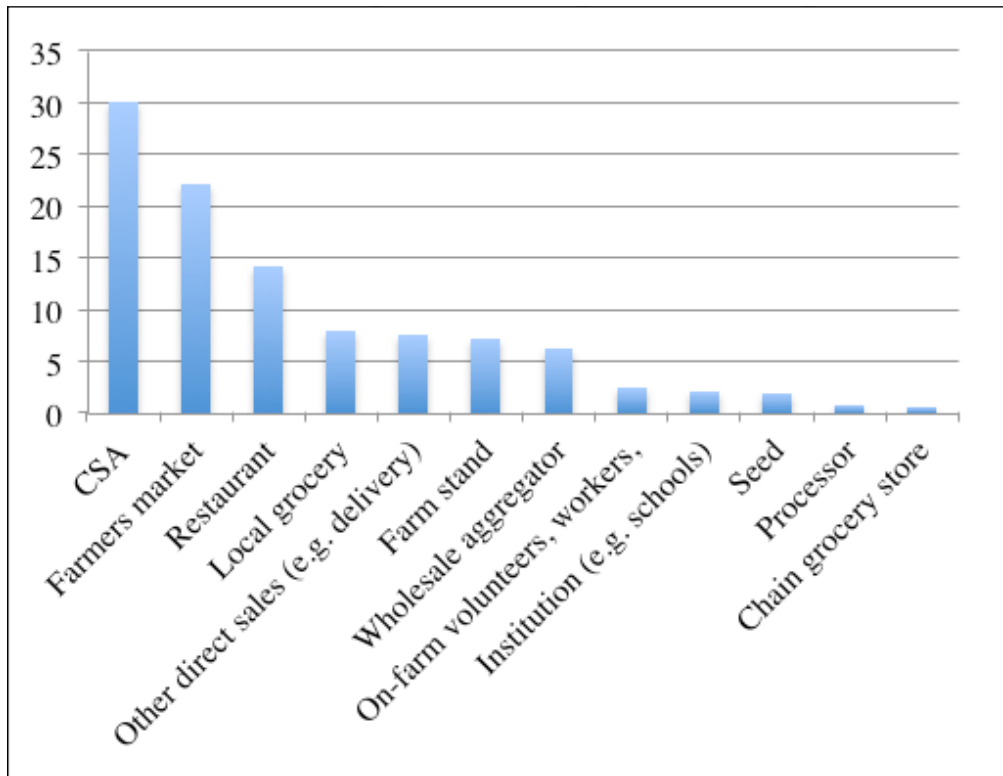
2016 Organic Growers Survey

Section one of the survey asked respondents for basic demographic information. Among the 156 respondents, the average farm size was 25.6 acres, with a range of 1 to 320 acres and a standard deviation of 50.1. The average acreage in organic vegetables was 10.7, with a range of 1 to 300 acres and a standard deviation of 30.9. The number of full time workers on respondents' farms ranged from 0 to 25, with a mean of 2.9 and a standard deviation of 3.8. The number of part time workers on respondents' farms ranged from 0 to 30, with a mean of 3.8 and a standard deviation of 6.0. In general, respondents were small to medium sized organic vegetable farms, with less than ten workers.

Respondents also were asked to estimate the percent of total production dedicated to various marketing outlets. These responses are listed in Figure 1, showing that, on average, respondents commit 30% of production to community

supported agriculture (CSA), 22% of production to farmers markets, and 14% of production to restaurants. This demonstrates that respondents are primarily engaged in direct marketing to consumers, rather than marketing to wholesalers, grocers or institutions.

Figure 1. Mean Percent of Production per Marketing Outlet



Next, respondents were asked a series of questions about how they make crop variety decisions:

1. What information about a variety do you need before trying it?
2. For the varieties you use or consider using, what characteristics are important?
3. For varieties that are only available as conventional seed, what are some reasons that may prevent you from trying an organic variety to replace it?

The first two questions yielded similar answers about the trait information most important to growers when they are considering trying a new vegetable variety. These responses were coded and analyzed together, to create the word map in Figure 2. Some responses have been abbreviated to fit the map. Predictably, days to maturity, disease resistance and yield were top variety traits that farmers wanted information on to guide their variety decisions. Flavor, however, was the top trait of interest for organic farmers, suggesting that the productivity characteristics of vegetable crops matter slightly less to direct market vegetable growers than the quality characteristics which attract and retain consumers.



Figure 2. Word map of responses to the questions: what do you need to know before trying a new variety? And what traits are important?*

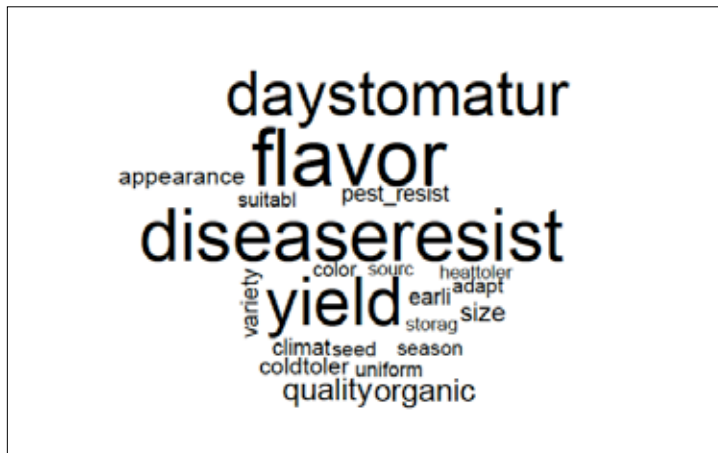
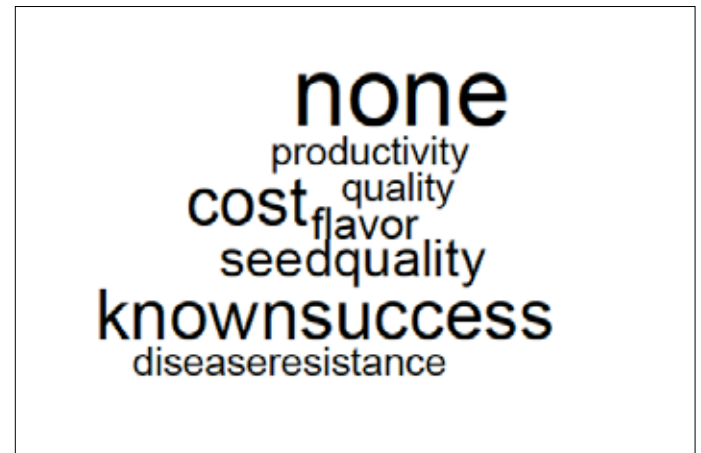


Figure 3. Word map of common responses to the question: what are some reasons you might NOT try an organic variety to replace a conventional variety?*



*Larger fonts indicate more common responses

Responses to the third question, about what keeps growers from trying an organic variety to replace a conventional variety, were analyzed to create the word map in Figure 3. Interestingly, the most common response was that there was no reason why respondents would not try an organic variety to replace a conventional variety. When barriers were identified, the lack of known success of a new organic variety, and the high cost of organic seed were most commonly cited. As will become apparent in subsequent sections, much of the discussion about a potential national variety trialing network centered on how to overcome these barriers to encourage more farmers to more readily experiment with and adopt organic vegetable varieties.

Respondents were asked to select from a menu of different crops, and to answer specific questions about trait priorities and available varieties for their crop choices. Respondents were encouraged to select crops considered most in need of improvement for organic systems. Respondents’ judgments about need for improvement likely considered common issues faced by growers that breeding may be able to address, as well as the economic importance of the crop selected to the respondent. Table 2. contains responses for the five crops most commonly selected. These lists of traits factored into discussions at the summit described below about priority crops for the national variety trialing network..

Table 2. Priority and Most Difficult to Find Traits by Crop

Crop	Most important traits?	Traits most difficult to find?
Tomatoes	Flavor, disease resistance, consistency, productivity, earliness	Heirloom type with disease resistance, crack resistance, earliness, drought tolerance
Broccoli	Shape, uniformity, heat resistance, dense heads	Resistance to club root, black rot, drought and heat tolerance, field holding capacity, long season, some want side shoots, some want large uniform heads, organic seed and OP varieties
Peppers	Earliness, size, appearance, flavor	Earliness, blossom end-rot resistance, sunscald resistance, thicker walls, yield without plastic

Crop	Most important traits?	Traits most difficult to find?
Carrots	Flavor, storage, shape/appearance, strong tops, germination	Summer sweetness, flavor, weed tolerance, germination, strong tops, fewer days to maturity, OP varieties, organic seed
Onions	Flavor, size, storage are the most common, also downy mildew resistance, thrips resistance, days to maturity (early)	Downy mildew, thrips resistance, earliness, size, storage, drought tolerance, thicker necks, dependable sweet onion

These national trends mirror the findings of regional work identifying priority crops and traits for breeding and trialing in organic systems. The results of three other projects are included here to demonstrate regional variation in priorities and to illustrate the point that breeding for work organic systems must take regional variation in environments and markets into account.

Table 3. Priority Traits by Region and Crop

Crop	Northeast	Midwest	Northwest
Tomato	Blight resistance, grey mold resistance, greenhouse adaptation, crack resistance, yield	Non-cracking, better OG cherry varieties, mildew resistance, higher yield heirloom, hoop house production, holds flavor later in season, cross-category options, resists rot when not trellised	Disease resistance, earliness, seedling vigor, nutrient use efficiency, improved plant architecture, resistance to cracking, novelty, yield
Broccoli/ Brassicas	Stress tolerance, black rot/black leg resistance	Disease tolerance -- black rot, soft rot, pest resistance, cold tolerance, higher nutrition	Disease resistance, cold tolerance, pest tolerance, overall quality and consistency, nitrogen use efficiency, better OPs, flavor, increased, nutrition, yield
Winter Squash	Storage, downy and powdery mildew resistance, cucumber beetle tolerance	Storage, better flavor, better delicate, good buttercups, smaller size, cucumber beetle tolerance, cheaper seed, PM/ black rot resistance, earlier maturing	Disease resistance (powdery mildew and fusarium), improve storage, yield, quality, insect resistance, select for dryland production, improve architecture for harvest and weeds, synchronous flowering
Carrot	Flavorful colored varieties, strong tops, alternaria resistance, rust fly, flavor after storage	Alternaria resistance, rust fly resistance, storages, weed competition, flavor in colored varieties, consistence mixes	Flavor, weed competition, smooth roots, disease resistance, access to organic seed
Potato	Disease resistance, leaf hopper and potato beetle tolerance	Extreme earliness, later maturing reds, holds color, lower cost, multiple disease resistance	Fungal disease resistance, improved culinary attributes, overall quality, abiotic stress tolerance, pest resistance, nutrient use efficiency, viral and bacterial diseases

Crop	Northeast	Midwest	Northwest
Peppers	Strong structure, early harvest, consistent timing, maintain flavors, cool season production, weed competition, viral disease resistance	Thicker-walled roasters, shishito/padron for Midwest, open growth habit, stronger branches, stronger roots, less scald, lunchbox peppers, no-corking jalapeños, high yield bells, low temp tolerance, earliness, storage	(grouped with tomatoes in this survey; see above)
Onions	Thrip resistance, downy mildew resistance, storability, organic varieties, improved red onions, botrytis resistance, consistent size	Thrip resistance, hard necks to prevent rot, thin necks for dry down, storage, fungal resistance, holds shape in cluster plantings, good OP options	Flavor, storage of sweet varieties, thrips resistance, early maturing, pink rot and damping off resistance
Sweet Corn	(not discussed)	Less sweetness, earlier yield	Selection for organic systems, yield, water efficiency, reduce GM contamination, improved root systems, pest/disease resistance, diversity of sweetness genetics, uniformity

2016 Plant Breeder and Seed Company Interviews

Plant breeders and seed company representatives offered a unique perspective on the challenges facing the organic seed industry, and the role a national trialing network could play in facilitating organic cultivar development and release. Common themes included:

Open pollinated varieties -- Having more high quality open pollinated varieties of common crops, bred for regional adaptation and organic systems, would help bring organic seed costs down for seed companies and farmers, while encouraging more farmers to engage in seed saving and on-farm cultivar development.

Seed production traits -- The difficulty of producing organic seed often deters seed growers from producing a variety of organic cultivars in adequate volumes to meet the demand. Research on improving seed production traits for important organic cultivars might help insulate seed growers from the risks associated with organic production, thereby potentially increasing the availability and affordability of organic seeds.

More and earlier trialing in organic systems -- Many breeders and seed companies lack the capacity to trial breeding material in organic systems early in the breeding process, or to perform rigorous trials in diverse environments at any point in the breeding process. Greater access to affordable trialing infrastructure, and data-sharing across locations, would facilitate the release of organic varieties.

Farmer, breeder, seed company networking -- Independent breeders and farmer-breeders find it especially difficult to get promising new material in front of potential seed company partners. A stronger network would help strengthen these relationships.

Standard evaluation methods -- In discussing the possibility of a trialing network, many interviewees mentioned the need for some standardization in trialing methodology and evaluator training, to ensure that results from different locations are actually comparable and useful to the breeder. However, over-standardization could lead to a loss of regional relevance. A balance could be achieved by standardizing formatting and data reporting while allowing regional variation in management.

Regional vs. broad adaptation -- Interview respondents were often interested in improving varieties for a specific region of intended use, and wanted to know how this goal aligned with a trialing network with a multi-regional scope. The trialing network design must ensure that each region is able to define unique breeding priorities while still evaluating varieties against commonly established baseline criteria. Interviewees also emphasized that evaluating a regionally adapted variety in an exotic locale is not the same thing as shifting breeding priorities to achieve broad adaptation across a wide range of environments. Access to trials across regions could identify varieties that perform well in multiple regions without shifting the focus of breeders away from regional adaptation.

Summit Proceedings

The Organic Variety Trialing and Plant Breeding Strategy Summit was held in Madison, Wisconsin on February 22, 2017. Meeting attendees are listed in Table 4.

The goals of this meeting were to 1) define realistic objectives for the proposed national organic variety trialing network and awards system, agree on a basic structure for these programs, and articulate near-term next steps for bringing them into being.

Table 4. Meeting Participants

In Person Participants	Affiliation	Virtual Participants	Affiliation
Paul Betz	High Mowing Seeds	Nick Andrews	Oregon State
Jamie Bugel	UW- Madison	Chris Becker	Osborne Seeds
Keo Corak	UW- Madison	Heron Breen	Fedco Seeds
Brian Emerson	UW- Madison	Shaina Bronstein	Vitalis
Nicolas Enjalbert		Jason Cavatorta	Earthworks Seeds
Emily Haga	Johnny's Selected Seeds	Aabir Dey	Bauta Initiative
Thomas Hickey	UW- Madison	Cheni Filios	Ball Seeds
Terry Hodge	UW- Madison	Matthew Goldfarb	Fruition Seeds
Nate Kleinman	Experimental Farm Network	John Hart	Earthworks Seeds
Claire Luby	UW- Madison, Open Source Seed Initiative	Helen Jensen	USC- Canada
Virginia Moore	UW- Madison	Chelsey Lenczyk	Bejo Seeds
Adrienne Shelton	Vitalis	Ellen Leue	PanAmerican Seed
Phil Simon	UW- Madison, ARS	Jodi Lew-Smith	High Mowing
William Tracy	UW- Madison	Alexandra Lyon	University of BC
Aaron Whaley	AP Whaley Seeds	Michael Mazourek	Cornell

In Person Participants	Affiliation	Virtual Participants	Affiliation
Lindsay Wyatt	Johnny's Selected Seeds	Karen McSwain	Carolina Farm Stewardship Association
Pete Zuck	Johnny's Selected Seeds	Keith Mueller	KC Tomatoes
		Heidi Noordijk	Oregon State
		Andrew Still	Adaptive Seeds
		Don Tipping	Siskiyou Seeds
		Alex Wenger	Field's Edge

Table 5. Organizing Committee

Organizing Member	Affiliation
Julie Dawson, Chair	UW- Madison
Micaela Colley	Organic Seed Alliance
Ruth Genger	UW- Madison
Ken Greene	Hudson Valley Seed Co.
Kitt Healy	UW- Madison
Cathleen McCluskey	Organic Seed Alliance, UW-Madison
Laurie McKenzie	Organic Seed Alliance
James Myers	Oregon State
Lane Selman	Oregon State
Jared Zystro	UW- Madison, OSA

The meeting began with introductions, and a series of presentations from Julie Dawson, Kitt Healy and Ken Greene. The goal of these presentations was to clarify the mission, goals and objectives of the proposed trialing network, and to share the results of the organic growers' survey and plant breeders/ seed company interviews discussed above. The over-all mission of the proposed network is to grow a diverse and dynamic organic seed system, supporting thriving agroecological systems in North America. To this end we propose three project goals:

1. Facilitate development and release of new varieties for organic systems that meet farmers' regional needs at a realistic price point
2. Strengthen collaboration among seed system stakeholders, especially engaging independent breeders, farmer-breeders and students
3. Improve methodologies for decentralized trialing and selection

The following programs were proposed to achieve these goals:

1. A trialing network of five hub sites in California, Oregon, Wisconsin, New York and North Carolina, each sur-

rounded by a cluster of on-farm trials designed to suit regional needs. These initial hub sites are based on existing trials, but could expand to include other hubs as sites are identified with trialling capacity.

2. Variety trials for seed production traits at Organic Seed Alliance research farms in Washington (dry seeded crops) and California (for wet seeded crops), to explore the possibility of breeding to improve organic seed quality and yield. These locations were chosen as they are prime sites for seed production, thereby limiting environmental variables from more challenging climates.
3. Education programs to promote on-farm trials and breeding, led by Organic Seed Alliance and Open Source Seed Initiative.
4. A user-friendly and accessible database for easy data sharing across sites.
5. An organic variety recognition program, similar to the All-America Selections program, but with a different structure and intent.

Organic Variety Trialing Network: Proposed Structure and Considerations

The proposed organic variety trialing network would begin with five hub sites and a network of on-farm trial sites centered around each hub. Hub sites will be at university or non-profit research farms, where trials have already been conducted and scientific methods of trial management and data collection are practiced. Each hub site will grow trials for an established set of crops, beginning with three crop species, and expanding as the project matures. On-farm sites would grow a sub-set of trial species and varieties.

If the trial burden on hub sites is too heavy, it is also possible that each site could rotate crops every year, so that each priority crop is trialed for three years, and then rotated out for a few years before being trialed for another three years. This may allow trial sites to cover more species as needed. Seed companies present at the Summit suggest focusing crop trials on regions where specific crops are likely to perform well, to decrease the role of environmental variation in crop evaluation. There is also interest, however, in assessing genotype by environment interactions, which favors more and more variable trial sites. These needs will have to be balanced in the final trial structure.

Priority crops and traits will be determined at both the national and regional levels, with crops and traits considered most in need of improvement shared across sites, and some flexibility built in to meet regional needs. Hub sites will be mostly in the northern tier of the United States to begin, because of already-established trial sites, but would hopefully expand southward in later years.

It would be useful for data to be shared across sites, even if it cannot be combined for analysis. Data will be used to inform breeding decisions, and will be collected by trained personnel at each hub site. Rapidly sharing trial conclusions is important for seed companies needing make marketing decisions, but can be challenging with multiple crops needing attention at different times of the season. Real time data sharing options may help address this problem, as discussed below. Furthermore, qualitative traits such as flavor are just as important to breeders and seed companies as quantitative traits such as yield, and it is important to present qualitative traits in a conclusive way so breeders can easily act on the information provided.

While hub-site trials at research farmers will offer more reliable quantitative data, on-farm trials will help highlight regional needs and inform how varieties are analyzed in a given region. One idea is for on-farm trials to serve more as a “showcase” of trial varieties while hubs produce data for analysis. Though it is often anecdotal, on-farm trials and farmer input is critical for breeders. If possible, trends in farmer evaluations should be verified in research station trials. It is also important for farmers to access each others’ data, to be able to learn from other trials in the same region.

Important challenges were identified in the discussion about the trialing network structure. The issue of financial sustainability was frequently raised, with the more established seed companies present being willing to pay for trial submissions, but the independent breeders and smaller seed companies expressing concern about cost being a barrier to entering the program. There were also concerns about scientific rigor in the trials, and ensuring that trials are handled

as uniformly as possible across diverse sites. The diversity among locations also raised concerns about meeting different needs in different regions, and taking different management realities (such as planting times, etc.) into account for diverse locations. One final concern was in getting farmers to return data sheets. Some attendees have had more success in this than others, and many ideas were shared for how to incentivize farmers to return data.

Proposed Organic Variety Award

Ken Greene of the Hudson Valley Seed Company and non-profit Seedshed, led the discussion on the proposed organic variety recognition system, which would operate in conjunction with the trialing network. Among participants, there was enthusiasm for the idea of having some way to honor breeders' achievements in creating (or improving) outstanding varieties for organic growers. There was much discussion of the form that such a program could take.

The general idea proposed is to develop a program of recognition for organic varieties similar to the All-America Selections program, though with a much lower cost to entry, more farmer-focused criteria for awards, and with more recognition given to the breeders of outstanding crops. Criteria would be set by an advisory board of farmers, plant breeders and seed companies, based on crops and traits identified as in need of improvement for organic production. As with the trialing network, there would be need to be a balance between regional and national priorities. It is possible that some criteria would be based on the needs of a specific region, while others would focus on variety performance in nation-wide trials. Criteria could also include categories for best variety by a "farmer-breeder", most successful revival of an old variety or other cross-species categories to further incentivize and reward plant breeding for organics.

Ideally, some revenue from the sales of winning varieties would be shared with the recognition program. There was much discussion of the benefits of such a program for breeders and seed companies. Possibilities include: the ability to use the "award winning" label, publicity and promotion, assistance in connecting with seed companies to produce and market seed (especially for independent and university breeders). Meeting participants also noted the importance of considering the marketing value of runner-up varieties. These varieties may still have value for organic growers, and there should be an additional outlet (such as a newsletter) for highlighting such cultivars.

Several concerns were raised about the proposed recognition system that will be important for program organizers to keep in mind. There was some resistance to using the word "award" to describe the type of recognition the group wishes to bestow. A more inclusive word, that doesn't suggest something wrong with non-award-winning varieties might be preferable. Another challenge to this program would be maintaining seed integrity, especially for varieties that suddenly become popular. If the recognition program does not maintain some influence over seed production, sourcing and marketing for some time after the winners are announced, others may attempt to produce and sell low-quality seed of these varieties, or versions that may not be uniform.

There was also some debate about the role intellectual property should play in the trialing network and awards system. As one participant stated, "we are trying to build a community based on sharing," in service of organic farmers nation-wide. This ethos of sharing, make sometimes conflict with the reality of plant breeders and their institutions' need to earn royalties from successful varieties. It was agreed however, that it is critical to be inclusive of all breeders working in organics, and to accommodate the diversity opinions and realities that those breeders bring to the table. A code of ethics was proposed for the trialing network and award system, to establish norms for germplasm sharing and other resource control issues.

Narrowing in on Priority Crops and Traits

Recognizing that more discussion with regional stakeholders will be necessary before committing to an initial set of trial species and priority traits, this initial discussion focused on assessing the merits of eight potential target crops. Many of the Summit participants have experience conducting variety trials of at least one of these crops, and had valuable insights into the time, space and labor requirements for running trials, as well as the need for improvement in certain crop categories. Before beginning the discussion of specific crops, there was some conversation about

focusing on open pollinated (OP) vs. hybrid varieties, and whether to treat the two differently in the trials. It was determined that for some crops (such as broccoli) finding high quality OPs is a high priority, and may guide trial variety solicitations. In general, though, participants agreed that OPs and hybrids should be compared equally.

Tomato: Tomatoes are a high priority for breeding for organic systems in every region of the country. Flavor, disease resistance, consistency, productivity, and earliness are priority traits. It is suggested that cherry tomatoes or other small-fruited varieties be excluded from the trials due to the labor required to harvest.

Much of the discussion focused on the possibility of assessing disease resistance in different areas, since strains of common diseases vary. It is important to know what is likely to appear in each region, and each site's capacity for assessing disease (i.e. are inoculations possible?) in order to target scoring to appropriate pathogens. The methods by which disease resistance is scored, however, should be standardized across sites.

Broccoli/Brassicas: Broccoli is not as high value a crop as tomato, but it is a common crop identified and in need for much improvement for organic systems in virtually every region of the country. Head shape, uniformity, heat tolerance, head density, field-holding capacity and multiple cuts (side shoots) are identified as priority traits, as well as a number of disease resistances.

Summit attendees noted that most current broccoli cultivar development is focused on creating hybrids for large-scale production in California. There is interest in developing higher quality open-pollinated varieties. The Eastern Broccoli Project is working to develop some desirable traits for organic growers, but is geographically limited. Meeting participants agreed that more background research on available cultivars and ongoing breeding work is needed.

Winter Squash: Winter squash breeders present at the summit suggested that it may be in good candidate for the trialing network, since this crop would benefit from having training evaluators in multiple locations. That way, breeders would not need to make multiple trips to trial sites to evaluate plants in the field, at harvest, and after storage. Priority traits mostly centered on disease and insect resistance, especially powdery mildew. Look at how different varieties do in different storage arrangements would also be interesting, including assessing how well things cure in a high tunnel. *Cucurbita maxima* (kabochas, kuris, buttercups, hubbards) especially was identified as needing improvement for organic systems.

Carrots: Carrot is an important priority for organic breeding, particularly because some of the most popular carrot varieties are not available as organic seed. Flavor, storage, germination and *Alternaria dauci* resistance are priority traits for carrot improvement. Current project focus on flavor and weed competitiveness for organic production. Also, finding way to overcome seed production challenges would be very useful in supporting the organic seed industry. Queen Anne's lace makes it very difficult to produce seed unless isolation is possible.

Summit participants suggested that carrot may be a good crop to include in a later iteration of the trial, since there are multiple projects developing material for organic system currently. We want to avoid redundancy, and be ready to trial this new material when it is ready. Data from these other projects (such as the Carrot Improvement for Organic Agriculture project) could also be tied in to the trialing network, to make conclusions more meaningful. The need for a post-harvest storage trial was also mentioned.

Potato: While there is a great need for improvement in organic potato varieties, summit participants suggested that it might not be an idea crop for the early years of the trialing network. Seed potato quality would be an issue, likely requiring production by certified growers, which is difficult for varieties not yet on the market. Some states are beginning to require that certified seed be planted over a certain acreage, so sending seed across the network would be tricky and potentially risky for disease management. Furthermore, breeders would likely be from land grant institutions, and would be protective of their material. If potato does become a target crop for the trialing network, yellow

and red varieties would be a high priority. The Kenosha Potato Project is an amateur breeding network that would be interesting to connect with.

Onion: Onion is recognized across regions as a candidate for improvement for organic systems. Priority traits for onions include flavor, size, storage, downy mildew resistance and thrip tolerance (related to waxiness/glossiness). Summit participants noted that storage trials would be important for onions, and that the substantial number of independent breeders working on onions would make the trials interesting and useful. There was some discussion about how to deal with differing day lengths in different trial locations, as well as differing days to maturity among varieties. Participants suggested that this could be dealt with in the trial design, and in the data management. It was also mentioned that there is an effort in the northwest to improve short-day onions and conduct overwintering trials.

Peppers: Peppers were identified as a priority for improvement in multiple regions. Specifically, earliness, consistent size, appearance, open growth habit, branch strength and flavor were selected as key traits. Blocky green and red bell peppers are seen as particularly challenging for organic growers to produce, since they take a long time to mature and are prone to rotting. Improving earliness on bullhorn-shaped peppers, however, might be more realistic than focusing on bells. Hot peppers are also of interest, since much less data currently exists for this category than for sweet peppers.

Sweet corn: Sweet corn is primarily a breeding priority in the Northwest region, where it is grown extensively. There was some discussion of whether transplanting or direct seeding sweet corn would be best for a trial. More organic growers are transplanting now to ensure high yields and high quality. Regional variation in maturity dates and the importance of evaluating in specific market/environmental niches would make sweet corn a difficult crop to trial nationally. However, there is a great need for research and trialing to improve organic sweet corn seed production, which is currently very challenging, and presents a barrier to new cultivar development.

Though further evaluation is necessary, this discussion suggests that broccoli, carrots, sweet corn, and potato are probably not good candidates for the early years of the trialing network. Tomato, winter squash, onions and peppers should be discussed more as early candidates for the trialing network. Pepper appears to be the crop that would be easiest to implement as a pilot crop for 2018.

Data Sharing Options

It was agreed among those present at the summit, that the ability to rapidly share data and trial results would increase the program's usefulness to plant breeders and seed companies. For participants currently conducting trials, the effort required to collect, enter, organize, analyze, describe and release data mean that results are not often available the same season the data is collected. Seed companies hoping to make decision about marketing seed, this timeline can be too slow.

Ruth Genger and Julie Dawson led the discussion about data sharing. Using smart phone tools to electronically enter data into a shared and accessible platform would help alleviate the lag in data distribution. Others added that a highly standardized protocol and format for data collection and entry would have to be established to make this useful, and to make the data translatable across hub sites. It would also be important to collect weather data at each site, and tie it to each data collection event, to ensure that data can be interpreted in context.

Several data management tools were suggested during this discussion: ranging from Google sheets, Google forms (which can collect information in a Google sheet) and Dropbox, to programs like ClimMob, Fieldbook, and the International Breeding Platform IBP. It was noted that IBP offers easy analysis options, but has many technical issues for vegetable crops that are difficult to solve.

Summit participants also highlighted the importance of making data and data sharing accessible to farmers. Farmers

might also like to observe others' trial results mid-season, and be able to share their own experiences with a wider audience. It was generally agreed however, that farmers' data may require more time to sort through, code and collate, especially if it is more qualitative. A potential challenge to rapid data sharing, for farmers and researchers, is that it may create bias among participants. Considering this and the realities of conducting trials, having all the data compiled and available by the end of the season maybe more useful and realistic than real-time sharing. Representatives from Oregon State University mentioned that they are currently exploring the option to develop software to aid data collection for a harvest date modeling project. That software may be useful to the group moving forward.

Fee Structure and Funding Options

Cathleen McCluskey of Organic Seed Alliance led the conversation about fee structure and funding options. The group first compared the fee structures of similar organizations. The All-America Selections program (AAS) offers a sliding scale of entry fees for varieties, supposedly ranging from \$500 to \$20,000 depending on the size and scope of the company. The vegetable breeding institute funding model, on the other hand, is donation based, with a sliding scale based on company size. The Pacific Ag network charges \$2000 for trial entries.

More conversation among project leaders is necessary before a funding structure is determined for the trialing network. A range of \$70 to \$350 per variety, per trialing location exists, but a more detailed understanding of the projected cost of hub site management from each site will be necessary before a decision on national costs can be made. Some of the larger seed companies present suggested that they would be willing to pay whatever is necessary to ensure the success of the program. Especially if proper replication (by plot, variety, and location), timely communication, and photographs (to help avoid travel) were part of the package. Some statistical models can help maintain accuracy while reducing the number of reps needed. It was agreed that more general information on more lines is preferable to more specific and statistically powerful information on fewer lines, which might require an unreasonable number of replications.

One participant suggested selling produce from the trials to help support their operation, but this can be difficult to achieve for universities and other larger institutions. Sponsorship from larger organic companies or co-op associations is also an option. This would require careful consideration of which companies are approached for sponsorship, to maintain the independent voice and integrity of the project. Another way to reduce cost for small seed companies would be a kind of work-share, in which the seed company hosts a trial, or provides staff time to support a nearby trial. Reducing bias in this model may be a challenge. Revenue from the recognition program may be another source of minimal funding.

Conclusion and Next Steps

The general conclusion from the summit was that participants are enthusiastic about pursuing a national organic variety trialing program and some sort of affiliated recognition program for outstanding organic varieties and breeders. A series of "next steps" were outlined at the end of the Summit.

Working groups were established to discuss pilot trials at the hub sites, data sharing protocols, cost estimates for trials, surveying other related trial initiatives, communications protocols and a statement of ethics for exchanging germplasm and data. These working groups will convene in the fall and winter of 2017-2018 in preparation for the 2018 season.

The first "next step" would be to formally establish hub sites, each with an advisory board of local farmers, researchers, and breeders or seed companies. Each hub site would need to develop an estimate of the time and cost necessary to manage trials and collect the desired data. Participants agreed to discuss a potential 'pilot' crop in the 2018 growing season with a few varieties incorporated into existing trialing activities, to test data sharing strategies.

Formally selecting crops and traits for the early years of the trial is also a priority for the project leadership. This will be done in consultation with experts on each of the candidate crops discussed above, and in reference to the farmer

survey and plant breeder interviews. Surveying other complementary trialing initiatives is also a priority. This would help identify potential overlaps and complementarities, and reduce the risk of redundancy.

Setting up a website similar to Organic Seed Alliance's online platform is an important first step in implementing the program's communication strategy. Having project information housed online will help with outreach and participant recruitment. The website would also serve as a portal to the data sharing platform, which participants will continue to research and refine, ideally with the help of some data engineering students.

Finally, the group decided it is important to begin reaching out to partners in unrepresented regions. The South, Southwest, Mountain, and Central US were identified as locations for potential partnerships, as well as some sites in Canada, where partners affiliated with the Bauta Family Initiative on Canadian Seed Security have established trialing or seed production initiatives. While the project will still be limited in its early years to the five initial hub sites, it is important to build relationships with partners in other areas, both as potential future hub sites, and to ensure that the project remains as inclusive of organic seed organizations as possible.

References

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