Proceedings of the 9th Organic Seed Growers Conference

February 14 - 17, 2018
Corvallis, Oregon • Oregon State University

Synergy that Sustains

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Many thanks to the conference planning committee[1]
Micaela Colley, Organic Seed Alliance
Ken Greene, Hudson Valley Seed Library
Emily Haga, Johnny's Selected Seeds
Cara Loriz, Organic Seed Alliance
Claire Luby, Open Source Seed Initiative
Cathleen McCluskey, Organic Seed Alliance
Sapphyre Miria, Twin Oaks Community
Rowen White, Indigenous Seed Keepers Network

[1] We received 70 conference proposals. There were an additional 21 members of the organic seed community who reviewed these proposals and provided input on the agenda, including farmers, university plant breeders, graduate students, seed policy advocates, and representatives from the seed and food industries.

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History & Mission
Organic Seed Alliance's mission is to (OSA) advance ethical seed solutions to meet food and farming needs in a changing world. We accomplish our mission through research, education, and advocacy work that closely engages organic farmers and other seed professionals.

In 2002, the USDA National Organic Program implemented the organic seed rule requiring that organic producers use organic seed when available. As a result, the organic seed market expanded and demand for organic seed production and breeding education grew. OSA was formerly operated as Abundant Life Seed Foundation, a non-profit seed business. In 2003, a tragic fire resulted in the loss of Abundant Life Seed Foundation's seed collection. At that time, the board of directors launched OSA as a separate nonprofit organization to support the growing organic seed movement and the Abundant Life Seed catalog and business were sold.

OSA now has a long track record of serving as one of the leading organic seed institutions in the US. Each year, OSA educates thousands of farmers and other agricultural community members, conducts professional organic plant breeding and seed production research on multiple crops, and advocates for national policies that strengthen organic seed systems.

Vision
We believe seed is both our common cultural heritage and a living natural resource fundamental to food production. Proper stewardship of our plant genetic resources involves their conservation and careful management in a manner that allows seed to continually evolve with challenges of the environment, cultural practices of sustainable agriculture, and the need to feed people. Our vision is an organic food system that is built on a foundation of seed well-adapted to the regional climatic conditions in which it is sown.

Programs
Our **research** expands access to high-quality organic seed through research, development, and commercialization. We engage in participatory plant breeding projects that support organic seed systems and address regional and national seed and food needs.

We provide **education** and training that expands the foundation of organic seed systems. This includes providing technical assistance in plant breeding and seed production to farmers, students, seed companies, and others through workshops, consultations, and publications.

Our **advocacy** work promotes actions and policies that support the availability and integrity of organic seed by confronting the concentrated ownership of seed and protecting farmers' rights as seed stewards. We engage in policy initiatives, discussions, and research at the national level.

Learn more at www.seedalliance.org.

Conference Agenda — Wednesday, February 14

7:00a - 9:00a	Registration check-in for Seed Economics Intensive
8:00 a - 8:45a	Breakfast for Seed Economics Intensive participants
9:00a - 4:00p	Seed Economics Intensive

Thursday, February 15

6:30a - 7:30a	Check-in for Willamette Valley Seed Tour
7:30a - 8:45a	Check-in for Organic Plant Breeding Intensive
7:00a - 8:30a	Breakfast for tour and intensive participants
7:45a - 8:00a	Gather and depart for Willamette Valley Seed Tour
8:00a - 6:00p	Willamette Valley Seed Tour, sponsor: Oregon Tilth
9:00a - 5:00p	Organic Plant Breeding Intensive
9:00a - 5:00p	Registration check-in for main conference
10:00a - 5:00p	Trade Show set-up
6:30p - 8:00p	OSGATA Mixer at McMenamins on Monroe

Friday, February 16

6:30a - 7:15a	Morning meditation with Sapphyre Miria
7:00a - 8:45a	Registration check-in for main conference
7:30a - 8:45a	Scientific poster session set-up
7:30a - 8:45a	Breakfast
9:00a - 10:30a	Efficient Methods to Develop New Organic Cultivars: Case Studies of Breeding Strategies That Leverage Farmer Participation On-farm Testing Crop Planning for Organic Seed Growers Private Sector Solutions to Increasing Organic Seed Usage Seed Sovereignty Experiences from the Agricultural Biodiversity Community
10:45a - 12:15p	Welcome and keynote address by Edith Lammerts van Bueren

Friday, February 16 (continued)

12:30p - 1:45p	Lunch
2:00p - 3:30p	Systems-based Plant Breeding: Adding New Dimensions to Resilience Growing Strong Seed the Biodynamic Way Intellectual Property Rights and Public Plant Breeding: Opportunity or Oxymoron? Community Seed Systems: New Networks to Build Synergies Among Seed Stewards
3:30p - 3:55p	Coffee and snack break
4:00p - 5:30p	The Grain Revolution: From Seed to Plate (or Pint) Seed Production in Cages — Challenging, Fun, and Rewarding Emerging Technologies in the Development of New Plant Varieties Building Robust Seed Systems Across Canada: A Model for Bolstering National Seed Security
5:30p - 10:00p	Trade Show
5:45p - 7:15p	Organic variety tasting sponsored by Culinary Breeding Network
5:45p - 6:45p	Scientific research poster session
7:30p - 9:00p	Dinner

Saturday, February 17

6:30a - 7:15 a	Morning meditation with Sapphyre Miria
7:30a - 8:45a	Breakfast
9:00a - 10:30a	Leveraging Variety Trials to Advance Organic Seed Systems Funding and Commercialization Options for Participatory Organic Plant Breeding Addressing Intellectual Property Rights in Organic Seed Systems Building Relationships from Seed to Fork
10:45a - 11:45a	Keynote address by Congressman Peter DeFazio
12:00p - 1:15p	Lunch
1:30p - 3:00p	Behind the Scenes: Why Seed Companies Drop Beloved Varieties Microbial Hitchhikers on Seed: Friend or Foe? Protecting the Genetic Integrity of Organic Seed How to Succeed with Regional Seed

3:00p - 3:25p	Coffee and snack break
3:30p - 5:00p	Taking Tomatoes Totally Organic Organic Hybrid Seed Production in the US — Methods and Case Studies The Intersection of Plant Breeding and Federal Policy Cultivating Diversity in the Organic Seed Movement: Resilient Seeds and Diverse Communities
5:15p - 6:15p	OSGATA 2018 annual meeting (open to all)
5:30p - 8:00p	Seed Swap
5:00p - 9:00p	Trade Show
6:30p - 7:45p	Banquet dinner and Trade Show raffle winner
8:00p - 10:00p	Live music and poetry slam

Presentations — Page No.

Plant Breeding & Variety Trials

Seed Production

Seed Policy & Advocacy

Synergies that Sustain

Welcome to the 9th Organic Seed Growers Conference

Cara Loriz and Cathleen McCluskey, Organic Seed Alliance

Welcome to the 9th Organic Seed Growers Conference. We're honored that you've joined us here in Corvallis for this biennial event.

This year's conference theme – *Synergy that Sustains* – recognizes that the organic seed community is diverse and growing, and that differences in approaches, regions, and stakeholders are our strength if we focus and act on what connects us – on synergism.

By definition, "synergy" represents the interaction of elements (including organizations and individuals) that when combined produce a total effect that's greater than the sum of individual contributions. We believe that strengthening synergies within the good seed movement is essential to the sustainability of our agricultural system and food supply.

We also believe that to foster synergies, actions must focus on generating more diversity in genetics, and in expanding partners involved in breeding, seed production, and policy advocacy. Both competition and coordination are healthy factors in any seed system, but the benefits must be shared. In the words of author Barb Rententbach, "A designed beauty of synergy is that it serves only to add, never subtract."

It is in this spirit that our conference committees have put together a stellar lineup of speakers and workshops to support the success of seed growers, seed businesses, plant breeders, policy advocates, and others who are committed to healthy seed systems that are responsive to the needs of organic farmers and the people they feed.

Our community is confronting a time of many changes: more consolidation in the seed industry, the patenting of plant genetics, insufficient public research dollars, and a dysfunctional Congress that seems to convene and act in fits and starts.

That's why we're thrilled to have Congressman Peter DeFazio join us here in his district as our conference keynote. He has long been a champion for organic farmers in Congress and will be addressing participants on Saturday about the Farm Bill and how we can support policies that advance organic agriculture and public plant breeding.

There are a number of events on the agenda that are new this year. Don't miss the Culinary Breeding Network's variety tasting with Chef Tim Wetzel on Friday night; our bigger and better trade show and raffle throughout the conference; and music and a poetry slam on Saturday night. We're also happy to provide the Grassroots Bookshop, where you can build your personal library with new and old book titles on all things seed. And don't forget to visit our Synergy Space, where participants can share inspirations, develop project ideas, strategize policy needs, and connect with other seedheads.

Many thanks to our 30 sponsors and conference co-hosts: Oregon State University, eOrganic, and Washington State University. Thanks to eOrganic, select workshops will once again be de-

livered online to expand our conference reach. And thanks to our hard-working planning committee: Micaela Colley, Cara Loriz, and Cathleen McCluskey of Organic Seed Alliance; Ken Greene of Hudson Valley Seed Library; Emily Haga of Johnny's Selected Seeds; Claire Luby of the Open Source Seed Initiative; Rowen White of Indigenous Seed Keepers; and Sapphyre Miria of Twin Oaks Community. We also extend our thanks to overwhelming public input and over 30 proposal reviewers who provided feedback in shaping this year's agenda.

Lastly, we want to thank YOU, our participants, for bringing your expertise to this gathering. Your knowledge, experience, and vision are guiding us into the future. You are our community's greatest asset. Organic seed is at the cutting edge because of your leadership. We'll continue to bring inspired people together through events like this to ensure that synergies emerge in ways that sustain our seed, food, people, and planet.

Efficient Methods to Develop New Organic Cultivars: Case Studies of Breeding

Julie Dawson, University of Wisconsin-Madison; Michael Mazourek, Cornell University; Jared Zystro, Organic Seed Alliance and University of Wisconsin-Madison

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Plant breeding is an exercise in efficiently managing limited resources. You only have so much space, so much labor, and so many seeds. This is even more so the case when developing varieties for organic systems, where the pool of resources is much smaller than for conventional breeding. As we learn more about the genetics of the crops we work with, there are more opportunities to use genetic information to develop crops that meet the needs of organic agriculture while still honoring the fundamental philosophies of the organic movement.

We often describe the inheritance of plant traits as either qualitative traits (fall into categories and are not affected by the environment, like fruit color) and quantitative traits (that have a continuous distribution and are environmentally impacted, like yield). During the process of plant breeding we work with both types of traits and the ability to predict the phenotype of a plant while it's still a seedling can save much land and labor. For example, winter squash plants each occupy at least 10 square feet, require hand pollination, and important traits — like disease resistance, quality and storage — don't reveal themselves until much investment is made on plants and the majority are discarded as being inferior.

Marker assisted selection (MAS) is a technique that is effective for simply inherited, qualitative traits. If one or two genes control a trait, and they are known, a diagnostic tool can be created that will test a leaf from the plant to determine which form of the gene (allele) it carries and only those plants with the desired characteristics would be transplanted to the field and pollinated. For example, powdery mildew resistance in squash is controlled by a single dominant gene. If you crossed two commercial hybrids together, in the next generation ¼ of the plants would be true breeding resistant, ½ would be resistant but carry the allele for susceptibility, and ¼ would be susceptible to powdery mildew.

The Mazourek group developed this tool for powdery mildew resistance in squash (http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0167715). Now, for about $5 per plant a squash breeder can send leaves picked from their squash seedlings to a diagnostic lab and get these results. If only true breeding resistant plants are chosen, then this test only needs to be done for one generation unless other susceptible parents are crossed into the population in the future. We are currently working on similar tools for spinelessness, virus resistance, rind color, bush habit, and other traits. For all the other important quantitative traits we use phenotypic selection and have used genomic selection effectively as well.

Genomic selection methods rely on markers that are distributed across the genome of a breeding line or variety, producing a genetic "fingerprint." These markers are then used to calculate how related each breeding line is to all the other breeding lines in the program. Genomic predictions are based on the assumption that close relatives will have more similar performance than less related lines, which is definitely an assumption, but is often a reasonable one. The in-

formation on genetic relatedness of the breeding lines is used in combination with information on performance of relatives in the field (phenotypes) to improve estimates of how new lines will perform before they have been extensively tested in the field.

There are two ways this might be used to benefit organic breeding programs. One is in reducing the time it takes to identify promising lines because we can use information from relatives to improve our guesses of what will make good parents or which lines are most likely to succeed in the field. The other is in increasing the number of lines that can be trialed by using information from relatives to reduce the need for replication of lines in the field. By trialing more lines rather than extensively replicating fewer lines, breeders can potentially make faster progress. As the cost of genotyping comes down, it is quickly becoming less expensive to genotype a line than to observe it over a season in a field plot, so if even one replication could be eliminated then the genotyping would be cost effective.

For example, as part of the Northern Organic Vegetable Improvement Collaborative (NOVIC), the University of Wisconsin – Madison's sweet corn program conducted organic trials of 40 sweet corn inbreds as well as 100 hybrid offspring in 2015 and 2016. The results of these trials, in combination with genotyping, were used to accurately predict the performance of many new hybrids and open-pollinated populations.

The benefits of these tools are not just limited to reducing population sizes in the field, they also enable recurrent selection. We recognize that while self pollination is an effective way to stabilize selected plants, it does not lead to improvements year after year like recurrent selection. Recurrent selection is limited by the number of breeding products one takes on in a crop because of concerns with cross pollination. Both MAS and GS allow the identification of the plants to be crossed before flowering and allow plant breeders to work with multiple recurrent selection populations.

Because budgets for organic breeding programs are often much smaller than those for conventional programs, it seems worth testing whether these strategies can help improve our ability to select varieties with exceptional performance in organic systems. The use of this type of genomic prediction would not replace field trials or the field phenotyping of selected lines. However, these strategies remain to be field tested in breeding programs to determine whether they are truly helpful for organic breeders. Several public sector programs are currently doing this and we will cover these examples in this workshop.

Systems-based Plant Breeding: Adding New Dimensions to Resilience

Edith Lammerts van Bueren, Wageningen University & Louis Bolk Institute

Correspondence: E.Lammerts@louisbolk.nl

Abstract: Current agriculture is contested and is under pressure to comply with the UN Sustainable Development Goals, aiming not only at ecological but also at societal resilience. To what extent is the plant breeding sector engaged? What can or should plant breeding contribute to issues such as ecosystem services, food sovereignty, and social justice? These goals are complex and require an integrated approach and a co-learning process to navigate through a diversity of future directions for the plant breeding sector. Also, the organic sector is challenged to make further progress to become societally more relevant while focusing on the Sustainable Development Goals. This new concept is elaborated in a scientific paper that is currently under review and will hopefully be published later this year.

Reference:

Edith T. Lammerts van Bueren, Paul C. Struik, Nick van Eekeren, Edwin Nuijten. Towards ecological and societal resilience through systems-based plant breeding. A forward-looking review (submitted to a scientific journal, under review).

Multi-actor Research for the Renewal of Minor Cereals in the Western Part of France

Nelson Daurelle, INRA France; Goulven Maréchal, FRAB; Franck-Emmanuel Leprêtre et Florent Mercier, Triptolème; Véronique Chable, INRA France

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Summary

A multi-actor participatory action-research project aims to achieve the "renaissance of minor cereals" in the Northwest of France. Conservation, selection, multiplication and production of five under-utilized or forgotten crops (spelt, einkorn, rivet wheat, buckwheat and rye) are fostered within networks of diversified actors and local food chains and through development of five products (flour, bread, pancakes, pastas and biscuits).

This project is implemented jointly by three groups of partners: the FRAB (Regional Federation of Organic farming of Brittany), Triptolème (an association of farmers, bakers, processors and consumers for the development of cultivated biodiversity and on-farm research) and researchers. It is associated with the European project DIVERSIFOOD (http://www.diversifood.eu/), which supports high-quality food and on-farm breeding of under-utilized species to enrich the diversity of crops grown within different agro-ecosystems through a multi-actor approach.

Our five minor species already have existing or potential outputs thanks to pioneers' initiatives within the members of both Breton associations. In the context of the rapid growth of the organic sector in France, the first objective is to identify the obstacles and levers for the use of minor cereals by (i) farmers, thanks to on-farm breeding of adapted crops and varieties, and (ii) consumers, via products that should be economically accessible and consistent with their food habits and their nutritional needs. Minor cereals development is providing opportunities for organic farmers to diversify crops and market opportunities into short and local food chains and to strengthen the link between public research and local farmers' groups.

1. Introduction

Diversity is the cornerstone of a sustainable, organic agriculture (Hole et al, 2005). Since 2000, European farmers have actively organized associations and networks to renew cultivated diversity.

Recovering cultivated diversity is one important issue to boost sustainable and adapted cropping systems and a resilient food system. This challenge calls for all citizens' commitment, and then a multi-actor and participatory action-research is preferred to cope with the needs of the overall food chain and to accompany locally adapted experience. In the context of the rapid growth of the organic sector in France, and specifically in Brittany, we will describe one project which aims to achieve the "renaissance of minor cereals" in the Northwest of France. It is supported by both national and European funds. Minor cereals development would provide opportunities for organic farmers to diversify crops and market opportunities into short and local food chains and to strengthen the link between public research and local farmers' groups.

Most of these Breton farmers are engaged in regaining peasant agriculture attached to the development of their territory. In French, the words “pays” (landscape) and “paysan” (peasant) have the same root. The “paysans” aim to give value to their “pays,” and thus peasant seeds are one of their main inputs to anchor values and to increase efficiency of peasant agriculture. One definition of peasant seeds has been provided the French Seed Network (Réseau Semences Paysannes): "Peasant seeds are seeds of populations, reproducible by the farmer, selected and multiplied with natural methods available to every farmer in organic fields, gardens or orchards. They are freely exchangeable while respecting the rights of use defined by the collectives that make them live.”

This project, “renaissance of minor cereals,” is implemented jointly by three groups of partners: the FRAB (Regional Federation of Organic Farming of Brittany), Triptolème (an association of farmers, bakers, processors and consumers for the development of cultivated biodiversity and on-farm research) and researchers. (1) Triptolème brings together more than 120 members with diverse profiles (farmers, farmer-bakers, gardeners, researchers, citizens and others) over three Western French regions (Brittany, Pays de la Loire and Normandy). (2) The GAB-FRAB (Regional Federation of Organic Farmers) network is joining Organic Farmers' Groups (GAB) of each department. It has a trade union vocation defending the interests of organic farmers. (3) Then, our research group of INRA has initiated participatory research for peasant seeds since 2000 (Chable et al 2014). These three partners have collaborated within several participatory research projects since 2009. They are also associated with the European project DIVERSIFOOD (http://www.diversifood.eu/), which supports high-quality food and on-farm breeding of under-utilized species to enrich the diversity of crops grown within different agro-ecosystems through a multi-actor approach.

2. Objectives

At the beginning of the initiative, all the actors wanted to better understand the conditions of the renewal of minor cereals and to identify bottlenecks and opportunities for the use of minor cereals by (i) farmers, thanks to on-farm breeding of adapted crops and varieties, and (ii) consumers, via products that should be economically accessible and consistent with their food habits and their nutritional needs. Then the project focuses on the conservation, selection, multiplication and production of five under-utilized or forgotten crops (spelt, einkorn, rivet wheat, buckwheat and rye) within networks of actors and local food chains and through development of five products (flour, bread, pancakes, pastas and biscuits).

3. Methods

To reach the objectives, besides a desk study to better understand the history of minor crops, the actors needed to better know the economic and technical context through a broad survey and to evolve their organization to fit to local specificities. And, in parallel, they are exploring genetic resources and on-farm breeding methods to enlarge the diversity of these species.

3.1 – A survey was made up of "experts" through a dialogue with key representatives of project partners. The objective was to cover all the diversity of actors involved in the organic food chain from on-farm breeding to consumers. At the beginning of the project, 26 interviews were performed in the area covered by the 3 partners (e.g. Brittany, Normandy and Pays de la Loire in France).

3.2 – A new organization of the Triptolème association has been designed thanks to internal meetings for a more decentralized management. When it began in 2006, very few farmers initiated on-farm breeding; a centralized management has been established with a salaried animator. Lack of meaning and the increasing number of members has indeed called for several changes in the running of the association with a collegial management. Moreover, the territory is too broad and there is no central place for the storage of all populations and their efficient distribution in the network of farmers.

3.3 – An evaluation of available landraces and the research of new sources of diversity are explored collectively associating farmers and researchers. This activity is shared among local groups and has also been supported by other projects like "Sarrasin de pays," funded also by the "Fondation de France" and DIVERSIFOOD, a H2020 European project. These projects have also offered means to evaluate strategies of creating new cultivated populations.

4. Results and discussion

4.1 - Better knowledge of the recent history of the local food system

The deeper analysis of the historical and socio-economic context leads to some explanations of loss of interest of minor crops in the western part of France with (1) the decline and implementation of socio-technical locks and (2) the homogenization trend required by agro-food industrialization. The marginalization of minor cereals in Brittany began with the decline in the areas cultivated with rye and buckwheat since the end of the 19th century and during the 20th century. Before the Second World War, this change corresponds to the shift from subsistence farming to market-oriented agriculture. Following the first agricultural revolution, chemical inputs and mechanization made possible the extension of the production of root crops and soft wheat that were not possible before. These crops had a market value and replaced the minor grains mainly used for self-consumption. In the '60s, there was a massive increase in animal production allowed by agricultural machinery, artificial grasslands and annual forages such as corn. This animal specialization has created a technological lock-in situation for any "minor cereals" return. For example, about 70% of buckwheat used in Brittany is imported and no longer produced in the region whilst the emblematic dish of the region remains for Bretons and tourists the "galette de sarrasin" (a kind of buckwheat pancake) (Lepretre, 2016).

The globalization of trade and the industrialization of the agri-food sector have also contributed to the erosion of cultivated biodiversity (Biénabe, 2013). Even if the initial goal of the agri-food industry was to conserve and stabilize food, it is based today on the biochemical fractionation of raw materials and the standard reformulation of processed foods. These raw materials will be preferentially produced from highly productive species such as wheat or maize. This accentuates homogenization and standardization of the food chain and the loss of interest of "minor" species. During the last two centuries, consumers have replaced food from minor cereals by white bread made of soft wheat, which was associated with a higher "social status." In contrast, the minor cereals were considered as the cereals of the poor.

4.2 – Recent evolutions for consumption

Our survey has shown the same trends at the regional level as those that had been recently observed at the European level, with a growing demand for minor cereals that can be assumed to be linked to a new culture of food. In France, there is indeed a regression of animal products in favor of plant products and cereals, following the awareness of the environmental and health impact of a diet with too large a quantity of animal products (Forget et al., 2017). A European project, Healthy Minor Cereals (HCM), has studied the characteristics of this demand across Europe (Oehen et al., 2015). For all the cereals studied (oats, rye, emmer, spelt and einkorn), the report identifies a higher demand than supply at the European level. The first constitutive criterion of this application concerns nutritional aspects, such as high nutrient concentration and sensitivity to gluten. Nutrition and health issues are becoming a strong axis of change in demand. Minor and old cereals (peasant and ancient varieties of wheat, einkorn, spelt) are considered by consumers to have more digestible glutens, and some lack gluten, such as millet and buckwheat.

However, this demand partially linked to other criteria makes it less compatible with mass markets where major cereals (wheat, barley) are marketed. These include intangible criteria of naturalness, tradition and also the proximity of production. Among the criteria of naturalness are the demand for products in organic farming as well as considerations on breeding practices.

4.3 – Recent evolutions for production and market

For the long distribution channels, we have identified two approaches. The first one is adapting marginally its system to meet the increase in demand via the increase in storage infrastructure and the establishment of a bio-regional brand. The second is a regional reconfiguration because the increase in the area of minor cereals is favored by dialogue between the producers and the end-users. A trend for regionalization of the supply is a current lever. For the local market, the renewal of minor cereals is favored by more intensive relationships between networks involving farmers, artisanal processors, consumers and communities, such as Triptolème and the members of FRAB networks.

4.4 – Bottlenecks and needs

A first issue identified by farmers is the low availability of seeds. The initial samples of landraces from farmers or from genetic resource centers are very small. Low yields limit the quantities available for exchange, but also limits the number of multiplier-users, thus the quantities increase slowly.

Another major line of work identified by the project's partners is the investment in sorting and dehulling equipment needed to evaluate the end-use qualities of landraces and new populations bred by the farmers. This machinery investment is indeed a barrier for several of the minor cereals studied (einkorn, spelt, dehulling buckwheat and millet that some farmers wish to also explore). Since the material may be specific, the purchase of hullers could be shared by farmers in the Triptolème network and the GAB-FRAB network. Sharing material is widely recognized as a good starting point for collective organization.

4.5 – On-farm breeding and crop evaluation

The on-farm research actions have been planned within 6 local groups of the territory: (1) inventory of the populations available on-farm for the different species, observation of accessions from gene

banks and multiplication of the seeds for all populations; (2) in parallel with the multiplications and according to the availability of the seeds, agronomic tests will perform to innovate in terms of cultural management and selection of new populations (species association, mixture of varieties, composite cross populations, and more); (3) then, dissemination will be organized more widely with the associated practices and know-how within the networks.

Besides on-farm plant breeding and seed production, end-use evaluation will be performed: (1) trials will be set up to test the end-use qualities for bread-making, flour milling and the production of pasta, pancakes and biscuits; (2) sensory analyses will be performed to compare the organoleptic qualities of different populations, and (3) simple nutritional analyses will be carried out on the different products.

Conclusion

Besides the renewing of forgotten or untapped species, the secondary objectives of this project are multiple: (1) develop and sustain peasant seed networks linked to the Triptolème association and the French Peasant seed network in France, (2) offer organic farmers the opportunity to diversify their crop rotation and their outlets into short and local sectors; (3) strengthen the link between public research and local farmer groups, and (4) boost a new culture associated with food and help citizens reconnect the content of their dishes to a local and rural renaissance.

Acknowledgments

The project "renaissance des céréales mineures" is financially supported by the Fondation de France and by the European Commission DIVERSIFOOD 2015-2019: European Project (Embedding crop diversity and networking for local high quality food systems), Research and Innovation action (H2020 – SFS 2014 – GA 633571. www.diversifood.eu. The Fondation de France has previously supported the project "Sarrasin de Pays" (2013-2016) which offered means to initiate on-farm breeding of buckwheat.

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Facilitating Farmer Collaboration in On-farm Variety Trials: Lessons from Wisconsin and British Columbia

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Organic production systems are to varying degrees different from conventional production systems, and because of this, crop varieties may behave differently in each. Differences in variety performance between organic and conventional systems arise because each of these systems constitutes a different environment, and genotype by environment (GxE) interactions are common occurrences. Because of GxE, varieties bred in a particular environment will be best adapted and most productive in that environment. A variety adapted to an organic system will have a particular suite of traits that allow for maximum productivity. The particular set of traits that are important may vary from crop to crop as well as from farm to farm, but a general set of traits can be recognized. These include the ability of the plant to use organic sources of soil nutrients efficiently, to emerge with vigor and at high frequency without the use of seed treatments, to be competitive with weeds, and to withstand pests and diseases specific to organic production systems. Organic environments are less managed than conventional ones and consequently more variable. Nutrients may vary in time and space, fungicides and herbicides are not used and any pest control chemicals are considerably more benign than those used in conventional systems. Because of the variability inherent in an organic environment compared to a conventional environment, crops also need to be "robust" – in other words, they need to be able to perform stably when exposed to abiotic and biotic stresses that are not normally present in a conventional system. The need to breed in and for organic systems is the rationale for three projects described below.

The first is NOVIC (Northern Organic Vegetable Improvement Collaborative). NOVIC is in its second four-year cycle funded by USDA's Organic Research and Extension Initiative (OREI). It was originally funded from 2009 to 2013 to breed and trial five crops (sweet corn, pea, broccoli, butternut squash, and carrot) plus a farmer's choice crop in each region. Partners included Organic Seed Alliance, Oregon State University, University of Wisconsin-Madison, Cornell University and USDA-NPGS-Geneva. In each region, researchers worked with farmers in both breeding and trialling efforts. Trials were conducted to identify commercial varieties and breeding lines that performed best both regionally as well as nationally. A farmer participatory mother-daughter trial design was used. Participatory plant breeding approaches were used to breed organic adapted varieties among the five targeted crops. Most prominent among the releases from these efforts is 'Who Gets Kissed?', an open-pollinated (OP) sweet corn released by Bill Tracy at the University of Wisconsin - Madison. A couple broccoli OPs have been released by participating farmers and advanced breeding lines have been developed for peas, butternut squash, and carrots. The project also initiated an organic trial database and carried out a series of farmer participatory plant breeding workshops in each of the regions. In 2014, NOVIC was again funded using a similar model but with a different suite of crops (sweet corn remains, but new crops include bell peppers, delicata and acorn winter squash, tomatoes and cabbage). The first year of the project has been completed and plans are in place for the next year. Farmer participation in trialling and breeding remains but management of the daughter trials has been placed more in farmers' hands. New breeding methodologies are being applied in sweet corn, and a farmer participatory approach has been implemented to breed a low pungency "Fish" pepper.

The Tomato Organic Management and Improvement (TOMI) project is also a USDA-OREI funded project that applies an integrated and interdisciplinary approach to manage foliar diseases throughout the U.S. The project is led by Purdue University and partners include Organic Seed Alliance, Oregon State University, North Carolina State University and University of Wisconsin-Madison. It aims to deliver tomato cultivars with pathogen resistance and excellent flavor to organic growers. The project is centered around a series of variety trials performed across the country that includes new commercial materials, breeding lines and a population based on crosses between North Carolina inbreds and 'Crimson Sprinter' or 'Wisconsin 55'. Selections for pathogen resistance and quality from these populations made in 2015 are being grown in the greenhouse and intercrossed to create a new cycle to screen again in 2016. Additional objectives of the project are to conduct research to facilitate expression of induced systemic resistance, and to identify effective organic fungicides and biopesticides for control of pests and diseases in tomatoes.

A USDA-NIFA-Plant Breeding Foundational grant (Assessing GxE interaction and heritability of vegetable crops in organic versus conventional production systems) was received by University of Wisconsin-Madison and Oregon State University, and became active in the fall of 2015. The Plant Breeding Foundational program funds work that is more fundamental in nature. As such, while the project does have an objective of developing useful snap bean and carrot germplasm, its main aim is to compare selection in conventional and organic systems and its effect on traits derived both at the phenotypic and genotypic levels. One of the questions the project asks is whether there are differences in allele frequencies between populations selected in different production systems, and what might the key traits be? Breeders generally have a good idea of what traits are important in conventional systems but are less knowledgeable about what traits are important for organic production. This project seeks to understand that aspect in self-pollinated (snap bean) and cross-pollinated (carrot) crops.

Public sector breeding efforts aimed at developing vegetable varieties for organic production are increasing as demonstrated by the three projects listed above. They also are testing novel ideas and concepts about breeding and selection, and are beginning to apply some of the genomics/bioinformatics tools that are becoming available to breeders. These projects are by no means an exhaustive list and if one wishes to find other publicly supported breeding efforts, then a search of the USDA CRIS database (http://cris.nifa.usda.gov/search.html) can reveal these.

Development of a North American Trialing Network for Organic Varieties

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This is a synopsis of the report from a workshop on this topic in February 2017. The complete proceedings is available at dawson.horticulture.wisc.edu. Many thanks to all participants (listed in the full report).

Small seed companies, public universities, non-profits, 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 plant 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.

In 2016, a survey was conducted of organic market-growers as a follow-up to the regional listening sessions on breeding priorities. Section one of the survey asked respondents for basic demographic information. 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. 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. This was the targeted demographic of the survey. Next, respondents were asked a series of questions about how they make crop variety decisions.

Flavor was the top trait of interest for organic farmers, suggesting that the agronomic characteristics of vegetable crops matter slightly less to direct market vegetable growers than the quality characteristics that attract and retain consumers. Days to maturity, disease resistance and yield were top agronomic traits that farmers wanted information on to guide their variety decisions. Interestingly, when asked for what reasons they would not try an organic variety to replace a conventional one, the most common response was "none." 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. A national organic variety trialing network centered on providing reliable in-

formation to farmers would encourage more farmers to experiment with and adopt organic vegetable varieties.

The proposed organic variety trialing network would begin with regional hub sites and a network of on-farm trial sites centered around each hub. Hub sites will be at university, extension 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. 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 means that results are not often available the same season the data is collected. For seed companies hoping to make decisions about marketing seed, this timeline can be too slow.

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. Working groups were established to discus 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. Please contact Julie Dawson if you are interested in being involved.

High Methionine, N Efficient Field Corn from the Mandarin Institute/Nokomis Gold Seed Co.

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Need

Methionine is a limiting essential amino acid for organic poultry production and the use of synthetic methionine is being phased out by USDA. Nitrogen fertilizers used for corn production cause massive pollution of water that affects human and ecosystem health and produces nitrous oxide greenhouse gas.

Opportunities

The Mandaamin Institute is a nonprofit organization that developed high methionine, N-efficient corn that does not need as much N fertilizer. This was done by 1) coupling longterm corn breeding efforts under N-limited conditions, 2) breakthroughs in Near Infrared spectroscopic-based detection of essential amino acids, and 3) by breeding unique partnerships between corn varieties and a consortium of N_2 fixing bacteria that induce N fixation. The results are N efficient/N_2 fixing hybrids with 30% more methionine and 15% higher protein yield. Results suggest our hybrids can halve the need for nitrogen (N)-fertilizer use and improve the value of grain by $1.37/bushel and silage due to more protein, methionine, and greater digestibility. Ownership of the seed and intellectual property (IP) for seed and inoculate is given by the original breeder (Walter Goldstein) and Mandaamin to a startup called Nokomis Gold Seed Company, LLC (NG) in exchange for a 10% royalty from licenses and fees to the Mandaamin Institute. NG owns and will protect, produce, sell, and license inbreds, trademark natural traits, and license inoculate formula. In the US, NG has partnered with Foundation Organic Seed (FOS) to produce and market seed. NG will team with FOS to expand offerings to their existing clientele and to expand into large-scale organic poultry, conventional dairy, and conventional non-GMO markets.

Challenges

The hybrids are new. Though yields in small plot research and farms have been competitive they need to be tested on a larger scale to confirm that: 1) they can reduce the need for N fertilizer by half due to greater root growth, N_2 fixation, and use of the NG bacterial inoculate; and 2) to validate their nutritional and financial value. Furthermore, we need to develop funding, internal structures, and relationships with farmers, feed mills, poultry and dairy companies, and consumers that are in consonance with our mission and ethical positions.

Experience

We utilize an advisory team that includes seed company and business people. Our strategy for commercialization together with FOS is:

1. **Raise money to fund NG and Mandaamin Institute.** We are working with investors and a banker.
2. **Research and outreach effort providing information to farmers.** Yields of our hybrids will be tested in strip tests (funded by USDA-NIFA- OREI) with organic farmers in WI, IA, IL, NY and IN, the University of Illinois, and NG. Mandaamin Institute is researching N efficiency with organic farm-

ers in Wisconsin (funded by USDA-NIFA-SARE). Results will be presented at organic and conventional tradeshows and publications and through a mailing list. NG will trademark logos for the traits.

3. **Business-to-business efforts.** We intend to develop the natural methionine market by 1) answering industry questions about high methionine corn; 2) interacting with feed mills, poultry companies, dairy and poultry producers; and 3) getting grain to mills to supply major poultry companies. NG and FOS have begun communicating with feed mills, feed companies and egg companies on this strategy.
4. **Consumers and the Environment.** Relevant information will be shared with consumers, state and federal governmental agencies, and environmental organizations on reducing N fertilizer use and thereby water and air pollution. NG will interact with the National Organic Standards Board (NOSB) regarding the replacement of synthetic methionine.
5. **Quality Crop Club:** NG's "Quality Crop Club" is modeled on the apple clubs that have encouraged growth in the specialty apple industry. Farmers, seed and feed companies, and breeder members will have exclusive ability to buy or sell seed or grain. Legal arrangement (inbred registry, etc.) will provide limited rights and use to those members and in exchange end-users of the corn will pay a surcharge for the grain to support ongoing research and administrative costs. The model will protect intellectual property, enhance income, consolidate business, increase efficiency, and manage two-way flows of information. This model will be revisited as seed volume increases and partnerships with seed companies across the US, Europe, and elsewhere become increasingly complex.

How the Open Source Seed Initiative Works with Plant Breeders and Seed Companies

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OSSI is a 501(c)3 non-profit organization that fosters the growth of decentralized plant breeding and seed enterprises serving the needs of an agro-ecologically based and just food system through the development and release of open source plant varieties. Since 2014, we have built a network of 38 plant breeders who have released 382 new, open source crop varieties being sold by 52 seed companies located in the USA, Canada, Ireland, the UK and Australia. Over 90% of these varieties were selected and bred under organic growing conditions. Additionally, 95% of OSSI pledged varieties are bred by "freelance" plant breeders or through participatory projects.

Freelance plant breeders are defined as much through their diversity as through their similarities. Primarily, they're independent and not affiliated with institutions or universities. Some of them run small seed companies to sell the varieties they breed. Some of them are farmers who have plant breeding projects on their farms. From our experience working with many freelance plant breeders at OSSI, we have found that the OSSI Pledge works quite well as a release mechanism for their varieties. The OSSI pledge reads: "You have the freedom to use these OSSI-pledged seeds in any way you choose. In return, you pledge not to restrict others' use of these seeds or their derivatives by patents or other means, and to include this pledge with any transfer of these seeds or their derivatives." Thus, the only restriction on OSSI-pledged varieties is that there be no further restrictions on that seed or any of its derivatives. Primarily, plant breeders seem willing to release varieties through the OSSI pledge because they are ideologically aligned with the project and believe that plant germplasm should remain available to use now and into the future. However, in some cases release through the OSSI pledge has helped with the commercialization process. OSSI works with a network of seed companies in addition to plant breeders and adding varieties to the database serves as both a recognition of variety release as well as potentially fostering connections with new seed companies for release if desired by the plant breeder.

OSSI-pledged seed is considered to be "freed seed" rather than "free seed." That is, its use for any purpose cannot be restricted. It is important to understand that we use the word "freed," not "free," because we refer to freedom and not price. OSSI-pledged seeds are freed from the patents and licenses that can restrict use. The OSSI pledge is a commitment to foster unencumbered exchange of germplasm and the freedom to use the material for any purpose with the single proviso that by accepting the pledge the user commits to allowing others freedom to use the material or derivatives of the material, and perpetuates that status by always accompanying the seed with the pledge. OSSI understands that plant breeding can be a significant investment of time and money, and that commercialization and release of a variety can be a way of recouping some of those costs. To that end, OSSI accepts certain contracts or agreements to facilitate seed increase and/or to provide benefit sharing to breeders. OSSI permits any contract or agreement for seed increase and/or benefit sharing for OSSI-pledged varieties in which the restrictions on the use of the seeds are limited to the two contracting parties. OSSI does not accept arrangements in which there are restrictions on the seed that extend beyond the two contracting parties. Seed companies can pass no restrictions on to breeders or customers. From the point of view of breeders or customers, OSSI-pledged varieties must be unrestricted.

Northern Plains Sustainable Agriculture Society's Farm Breeding Club

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Northern Plains Sustainable Agriculture Society Farm Breeding Club

The Northern Plains Sustainable Agriculture Society (NPSAS) Farm Breeding Club (FBC) has been working to foster participatory plant breeding (PPB) collaborations between farmers, plant breeders and agronomists, seed companies, traders, processors, and consumers. Our focus has been on the critical gap in breeding "minor use" crops important to organic systems in terms of diverse cropping rotations. These minor use crops now have few, if any, plant breeders working for variety improvement within our land grant university system; in addition, any work that was being done on these crops was not focused on the needs of organic farming systems and the traits organic farmers require.

The FBC has conducted limited actual plant breeding but has identified useful varieties with traits of interest that are being increased and the seed provided to farmers. These varieties could be used as parents for breeding purposes. Our work has brought in significant grant funding but the logistics of this work has been challenging for the organization as a whole.

Now that we have seed of varieties of interest, the question is how to distribute that seed while generating funding streams to support ongoing work. NPSAS is not a seed company, nor does it seek to become one. The NPSAS board has had to work overtime to put policies in place to provide the guidelines for moving forward. The *challenge* is to balance our shared philosophy of keeping seed in the hands of farmers and in the public realm, while safeguarding the investment of the organization, our farmer members, and our collaborating plant breeders, research agronomists and their institutions.

NPSAS released a variety of wheat in 2007, named FBC Dylan, in memory of our lead researcher's son. FBC Dylan made a bold statement to the modern world, as it was released in the public domain. At the time of release, NPSAS drafted a letter to farmers growing FBC Dylan encouraging them not only to use organic seed, but to save seed and sell seed, provided they used proper seed protocol to maintain variety purity and ensure high-quality seed. The letter asked farmers to pay a 10% development fee on seed sales back to the FBC on an honor system to "aid in the development of seeds for the future of organic agriculture."

Two problems: Despite many promising marketable attributes of FBC Dylan, it has not gained the following the club had hoped and has not generated much revenue. It is not as simple as, "release it and sales will come." Suitable end markets need to be sought out and developed; at the same time varieties need to be promoted to find their place in farmers' fields. All this takes capital—not only economic, but social, human, and political capital to position the seed and leverage that natural capital. In our experience, people need help to do the honorable thing; they need to be reminded that much has been given them and that they need to give in return. However, work continues and lessons have been learned.

The challenge the club faces is how to balance work for the public domain staying true to our ideals with the need to leverage resources for ongoing work. One approach being vetted is to strike a balance between projects that are in the realm of "Seed for the Public Good" and projects that focus on "Commercial Seed Development;"projects focused on the expansion of genetics and seedstocks in the public domain and projects focused on closed loop programs that generate funding streams for the NPSAS FBC to continue its work.

Some of the tools we are exploring to accomplish this balance are licensing agreements, trademarking varietal names, and Plant Variety Protection (PVP). The proceedings of the 2016 Seeds and Breeds Summit on Intellectual Property Rights and Public Plant Breeding provides recommendations on best practices for intellectual property protection of publicly developed plant germplasm and is a resource.

One promising example is organic field peas, one of the projects the FBC has been working on in collaboration with a commercial partner, Pulse USA (PUSA). We have trialed and identified three pea varieties for release as certified organic, pedigreed seed; to be handled like any other certified seed program, with Foundation, Registered and Certified class seed. PUSA would license organic seed growers to conduct seed increases. The peas will only be available as certified organic seed; these varieties will not have a conventional counterpart. They will be PVP varieties allowing growers to save and use their own seed; they just cannot sell the seed. PUSA will provide a donation back to the FBC for every bushel of cleaned certified seed sold. PUSA envisions the possibility of some organic end users seeking Identity Preserved contracts for their specific needs. (End users of peas value product uniformity because soaking and cooking times can vary widely from variety to variety.)

Commercial partners, such as PUSA, have the bandwidth to market varieties; the FBC does not. The FBC is in discussion with other seed companies, traders, and food processors on other crops. Partnerships hold potential for additional revenue streams helping to make NPSAS, FBC projects, and our research partners' programs less dependent upon the granting world, while demonstrating long-term financial sustainability to our foundation funding partners.

Prairie Road Organic Seed

The other hat that I wear is that of our own seed company, Prairie Road Organic Seed. We began our work with seed in the garden—selecting varieties, selecting the best seed from those varieties, and eventually breeding some of our own varieties. The skills we developed and friendships forged in the seed world led to production contracts for organic garden seed companies as contract growers. We began introducing the varieties we had bred on-farm to these seed companies. Some of our farmer-bred varieties began gaining a following.

We began packing our own seed under our label, Prairie Road Organic Seed, in 2012. We continued to contract and grow these varieties for numerous seed companies. We also marketed our seed through the Family Farmers Seed Cooperative. We often sent seed to be included in variety trials with no formal agreements. In our experience, having agreements up front fosters

understanding and ensures that everyone will be operating by an agreed upon code of conduct. Codes of conduct and sample material transfer agreements would be a helpful resource.
One of the issues we have encountered is our OP varieties being marketed as "heirloom" seeds. Either there is a tendency to think that OP varieties must be heirlooms or it is an issue of failing to properly research the history of a variety. Once a variety is misrepresented in the marketplace, that error tends to proliferate.

Our varieties have been designated "open source" through the Open Source Seed Initiative. We support "freeing the seed!" There is a notion or tendency to think that "freedom to use" means *free*. There are a few seed companies that have voluntarily contributed a "breeder's share" of seed sales of our farmer-developed varieties back to Prairie Road Organic Seed to support our work. I would like to see this become our community's code of conduct. We have made this our farm's code of conduct: to provide a "breeder's share" based on our seed sales of a farmer-bred or PPB variety we have been granted the privilege of growing. Together, let us support the seed!

On-Farm Breeding Collaborations — The Johnny's Perspective

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Need

Retail seed dealers are constantly searching for products that are better tailored to meet the needs of professional growers. Sourcing products from traditional breeding companies has its limitations; these varieties are often bred in climates that don't reflect the conditions experienced by domestic growers, and usually they were not deliberately bred in organic systems. Few seed dealers have the budget or expertise to breed high-quality varieties on their own, and those that do may have a limited capacity to test them in varied environments. They may also be breeding in somewhat of a bubble, struggling to get the unfiltered input they need from real growers. On-farm breeding collaborations help hone in on important breeding targets by bringing together those with the critical need (growers) with those who have the resources to develop the varieties that meet those needs (the breeder).

Challenges

Many challenges must be overcome to make these projects work:

- Assigning work and resources in an equitable way.
- Managing lengthy and detailed timelines for development, trialing, production, and marketing.
- Overcoming geographic separation if it's not an entirely local effort.
- Ensuring that any licensing agreements support the financial well-being of the parties involved.
- Managing seed production:
    - Accurately forecasting sales to ensure appropriate scale of production.
    - Securing production ground and isolation/pinning if necessary.
    - Progeny selection, etc. for maintenance of lines (present and future).
    - Seed cleaning – proper equipment may be unavailable and/or prohibitively expensive.
- Trialing the variety in an appropriate range of climates and growing systems.
- If the variety is to be wholesaled, developing appropriate marketing materials.

Opportunities

A unique variety, proven by experienced growers to provide strong performance and value, will sell seed. Aside from performance, customers also appreciate how this type of project supports domestic variety development and seed production at a more "grassroots" level. Hopefully, the sales revenue and royalties generated by the project are enough to increase the growers' profits and provide meaningful funding to any non-profit(s) involved. This should, in turn, increase investment in seed production infrastructure, thereby improving conditions for future collaboration.

Experience

Rhubarb Supreme Swiss Chard: John Navazio (pre-Johnny's), OSA, and Nash's Organic Produce collaborated on a unique, high performing variety selected and produced organically in the Pacific Northwest. Price was based on what Nash's farm felt they needed to be able to invest in better cleaning equipment, so they secured more production contracts for like crops. OSA collects a royalty that will help fund future projects. Johnny's has a nice marketing opportunity with the storytelling. The primary challenge was ensuring the seed would be clean enough to meet Johnny's quality assurance standard.

Taking Tomatoes Totally Organic

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Introduction

The fact that tomatoes are easy to breed, coupled with the tremendous genetic variation that exists within the crop has resulted in many varieties of this crop. Tomato is a member of the nightshade family (Solanaceae) along with other food crops in this family being potato, pepper, and eggplant. However, tomato will not cross with these species. The scientific name for tomato is Solanum lycopersicum, but formerly was called Lycopersicon esculentum. Lycopersicum/lycopersicon means "wolf peach," the name being attributed to Galen from the 2nd century AD. The species originated in the New World where wild relatives are found mainly along the Pacific Coast of South America, but greatest variability within the domesticated crop is found in Mexico. Supporting the domestication of tomato far from its possible center of origin is the finding that while tomato shows a high level of visible (phenotypic) diversity, its levels of genetic diversity at the gene level is quite low relative to wild relatives. There are free living types of cherry tomato designated S. lycopersicum var. cerasiforme that can be found in Mexico and South America. These are thought to represent domesticated tomatoes that have become feral, but may in some cases represent the wild progenitor to tomato.

An extensive set of wild relatives can be crossed to tomato. Some can be crossed directly (although perhaps in only one direction) while others require the use of embryo rescue to obtain viable seedlings. These species provide a source of traits that may not be readily available within the cultivated species. The wild species can be divided into the colored fruited group (including S. pimpinellifolium and S. cheesmaniae) and the green fruited group (some members of which are S. chilense, S. peruvianum, S. lycopersicoides, and S. habrochaites). S. pimpinellifolium is sometimes cultivated in gardens as a "current" tomato, but the others generally do not produce edible fruit. These species have contributed resistances to such diseases as tomato mosaic virus, tomato spotted wilt virus, leaf mold, curly top virus, and late blight. Tomato breeders have also introgressed quality traits from these wild species, including increased soluble and total solids, high vitamin C content, increased phenolics and anthocyanins. Contrary to the paradigm of loss of genetic diversity through modern breeding, which is thought to be the case for most domesticated crops, tomato genetic diversity has actually increased in modern cultivars compared to heirlooms and land races. This increase is attributed to the introgression of genes from

wild species. Even though breeders are interested in a specific trait, the recombination process still brings along many additional genes from the wild species.

Tomatoes are diploids with 12 pairs of chromosomes. They are predominantly self-pollinated which naturally results in cultivars that are pure lines (the term "open pollinated" is often misapplied to this species). It is relatively easy and economical to cross by hand, so F_1 hybrids are a common form for contemporary cultivars. Most domesticated tomatoes have perfect flowers with the style and stigma surrounded by the anther cone. Because the sigma is not exposed to the open environment, it is uncommon for outcrossing to occur. This trait is a result of domestication with style length and ovary shape affecting the degree of outcrossing that might occur. Wild relatives and some cherry tomatoes have longer styles which places the stigma beyond the anther cone. These are more prone to outcrossing when pollinators visit the flowers. Tomato varieties with lobed fruit and fasciated stigmas are also prone to outcrossing because the flower is more open with the stigma exposed to the outside environment.

From a plant breeding standpoint tomatoes are an interesting crop because of the wealth of genetic resources and the extensive phenotypic variability. Numerous heirloom tomato varieties are available through seed catalogs and organizations such as Seed Savers Exchange. In the U.S., the USDA maintains genetic resources in two collections; one the Plant Introduction collection located at the USDA-NPGS-PGRU in Geneva, New York, and the C.M. Rick Tomato Genetic Resource Center on the University of California-Davis campus. The former collection has about 9,100 accessions of cultivated tomato while the latter focuses on wild species (~1,200 accessions of 13 species) and genetics stocks (~1,800 accessions). The tomato genome has been sequenced and the number of molecular markers available for genetic studies has increased dramatically in recent years. Scientists are using the genome sequence to associate underlying genes with expression of traits to increase the efficiency of the breeding process.

Being a self-pollinated crop, the most useful breeding methods for tomato are pedigree, single seed descent, and backcross breeding. Depending on the market class, different traits may be preferred. For example, paste tomato plants generally have determinate growth habit and fruit with relatively few locules, thick pericarp walls, relatively little placenta (gel surrounding the seeds), and relatively small, oblong uniform-ripening fruit. Paste varieties often have a jointless peduncle so that the calyx pulls off when the fruit is detached from the vine. On the other hand, slicer tomatoes can be quite a bit more variable, but tend to have larger fruit on indeterminate vines with a higher ratio of placental to pericarp. Since most flavor components are located in the placenta, slicers are usually quite a bit more flavorful than paste tomatoes. One trait that has been incorporated into many OSU varieties is parthenocarpy, or the ability to set fruit without pollination. The trait is useful for varieties grown in the cool springs and summers of the Pacific Northwest as it allows for earlier fruit set than conventional tomatoes. Disease resistances are important in tomatoes with most contemporary varieties having Verticillium, Fusarium wilt, nematode and tomato mosaic virus resistances. In the Pacific Northwest, important diseases include early and late blight.

Organic growers have indicated that tomatoes are a high priority for developing varieties that are suitable for organic production systems. In the next two sections, we briefly describe activities funded by the USDA-OREI federal grants program and the USDA SARE program.

TOMI: Tomato Organic Management and Improvement Project

Background and introduction

Demand for tomatoes grown using organic practices and sold through local, direct-market channels is rapidly increasingly across the U.S. Organic tomato growers report that effectively managing foliar diseases — including late blight, early blight, and Septoria leaf spot — while delivering tomatoes with good fruit flavor to satisfy customers shopping in local markets are their biggest production challenges. This project brings together a multidisciplinary team of researchers from across the U.S. to develop short, medium and long-term solutions to these challenges. This project addresses these challenges through three project areas: 1) selecting improved varieties using a participatory breeding approach; 2) identifying effective biopesticide and biostimulant combinations, and 3) identifying factors and mechanisms regulating induced systemic resistance.

Selecting improved varieties using a participatory breeding approach. Organic tomato growers need improved varieties that are resistant to new races of plant pathogens and have outstanding fruit flavor. Participatory breeding offers an ideal approach to meet these goals.

Objectives

- Select new disease-resistant, fresh-market slicer tomato varieties with good fruit flavor in collaboration with local growers.
- Quantify stability of genotype performance across variable environments.
- Increase the practice of participatory plant breeding and adoption of new tomato varieties.

Results to date

The best breeding lines were crossed during winter 2015 - 2016 to increase expression of desirable traits.

- New crosses were tested in 2016 & further selected based on molecular markers for disease resistance.
- Selection among segregating populations continued at research stations and in on-farm trials during 2017. The plant plants in each location from best overall populations are being advanced during the winter of 2017 - 2018.

Identifying effective biopesticide and biostimulant combinations. Organic tomato growers need alternatives to copper fungicides that control foliar diseases without negatively affecting soil and water quality. Biopesticides and biostimulants have potential to address this need.

Objectives

- Identify biopesticides and biostimulants that control foliar diseases in diverse environments.
- Determine whether combining various products can increase disease suppression and enhance plant performance.
- Characterize potential relationships between these products and plant growth promotion and/or induced systemic resistance.

Results to date

- Several bioproduct combinations were as effective as copper in suppressing foliar diseases in North Carolina.
- Prestop, a biofungicide containing Gliocladium, suppressed foliar disease in both Indiana and North Carolina.
- Foliar disease severity in tomato cv. 'Oregon Spring', following treatment by organic fungicides in Indiana and North Carolina, and foliar disease symptoms.
- Field trials were repeated during summer 2017 with alternative treatments designed to improve disease suppression.
- Greenhouse trials were conducted to characterize potential mechanisms contributing to disease suppression in response by Prestop.

Identifying factors and mechanisms regulating induced systemic resistance. Induced systemic resistance (ISR) is an enhanced defensive state in plants mediated by microbes. Research is needed to include this trait in breeding programs and facilitate practical application in the field.

Objectives

- Identify tomato genotypes that respond to ISR, reducing susceptibility to multiple pathogens.
- Quantify molecular mechanisms that regulate ISR expression and develop new molecular markers to better quantify ISR expression in research trials.
- Identify soil management practices that increase beneficial microbes and enhance ISR in the field.

Results to date

- Benefits of Trichoderma harzianum inoculation on plant biomass differed among tomato genotypes.
- T. harzianum differentially affected susceptibility to Botrytis and Phytophthora among tomato genotypes. Impact of Trichoderma inoculation on root and shoot biomass and lesion spread by the pathogen Botrytis cinerea in four tomato genotypes spanning a range of domestication.

Northern Organic Vegetable Improvement Collaborative

The Northern Organic Vegetable Improvement Collaborative (NOVIC) is a project to support breeding and trialing of vegetables to identify (and breed) those adapted to organic production. With multiple institutions involved, there are five main breeding and trialing efforts. The mix of crops was chosen through feedback from organic growers and seed companies. Tomatoes were chosen as a result of a survey of organic growers in Wisconsin, where disease resistance was determined to be their number one priority and tomatoes were their most valuable crop. Tomatoes ranked second in priority for organic plant breeding.

What are the needs that organic growers have expressed? By far diseases are one of their greatest concerns. In tomatoes, the most important diseases include late blight (Phytophthera infestans), early blight (Alternaria solani), and septoria leaf spot (Septoria lycopersici). Another key area for tomato improvement was flavor, according to Organic Seed Alliance's *State of Organic Seed* report. Many fresh

market tomato growers grow heirloom varieties for their flavor, as they are unhappy with the inferior flavor of the multiple disease-resistant tomato varieties currently available. In addition, quality traits, such as deep red color, crack-resistance, and a firm but juicy texture, are required for fresh market production. The objective of the OSU tomato breeding program within NOVIC has been to develop high-quality, attractive slicer tomatoes with late blight resistance evaluated through on-farm, multi-location participatory trials.

The OSU tomato breeding program has had an ongoing effort to breed for resistance with selection in organic systems beginning in 2008. 'Legend' slicer tomato with Ph-2 resistance was released from the OSU breeding program in 2000. OSU researchers have pyramided additional resistance genes onto Ph-2, including Ph-3, Ph-5, and quantitative resistance from Solanum habrochaites. Several advanced breeding lines have been evaluated in NOVIC trials since 2014. One (S200-1) has Ph-2 combined with S. habrochaites resistance and two additional lines that combine Ph-2 and Ph-3 (LB8-3-1-1-1 and LB8-7-1-1-1) were evaluated in NOVIC variety trials in recent years. In 2017 trials, S200-1 and OSU-LB8-7-1-1-1 were again tested for performance. S200-1 is a medium sized red slicer with bush habit and late blight resistance in the field equivalent to commercial hybrids with heterozygous Ph-2/Ph-3 resistance.

NOVIC trials are based on a mother-daughter design, with hubs in four regions (Washington, Oregon, Wisconsin and New York) with several daughter trials in each region. We also have had a satellite trial in Colorado for the past two years. The trials have consisted of about 10 entries with checks, commercial varieties and experimental lines from the OSU breeding program. The trials provide an opportunity for widespread testing of experimental materials as well as identifying promising commercial varieties that may not be produced yet as certified organic seed. In general, there has been quite a bit of variability across regions. For example, in 2016, based on the NOVIC research station trials in Washington, Oregon, Colorado and Wisconsin, there were significant differences between entries for total harvestable weight. There were also significant interactions between entry and location for marketable weight, and this interaction was due to changes in rank as well as magnitude. Of the ten varieties grown at these four locations, there was no variety that consistently had the largest total marketable weight. In Colorado, 'LB8-3-1-1-1' had the most marketable fruit. In Oregon, it was 'Mountain Merit'. In Washington, it was 'Plum Perfect'. In Wisconsin, it was ' NC12TMV007x141233-62'.

High tunnel and field tomato production in the Upper Midwest

Many organic and low-input farmers in the Upper Midwest are using high tunnels (hoop houses) to extend the season for tomato production. We are using participatory research methods to evaluate tomato varieties for agronomic traits, disease resistance, flavor and quality for local and regional markets in the North Central Region. We compared tomato variety performance in high tunnels and open-field management, and developed a network of farmers who are evaluating varieties in on-farm trials. We assessed quality and flavor by using a combination of farmer evaluations, research staff evaluations and Madison area chef evaluations, in addition to several public taste tests at field days and other events. The dramatically higher yield in the high tunnel was due to both an extended season and substantially lower foliar disease incidence in the high tunnel environment. Despite the generally held opinion that modern varieties are higher yielding and more disease resistant than heirlooms, while heirlooms are more flavorful, we found more variation among varieties within these groups than between them. In addition to our findings on tomato variety performance in the Upper Midwest, we have

improved our participatory trialing methodology to more meaningfully involve farmers and other experts in variety trialing research, and created a participatory trialing network for tomatoes and other crops in the Upper Midwest.

Methods

Production

At the West Madison Agricultural Research Station, we compared hoop house and open-field production of sixteen tomato varieties on certified organic land from 2014 - 2016. Trials were conducted as randomized complete block designs with two replications in each management system (hoophouse and open field). Check varieties 'Big Beef' and 'Pruden's Purple' were replicated four times in each management system.

Tomatoes were harvested weekly from mid-July to mid-October at West Madison, and three times from mid-September to early October at Rock County. The Rock County trials did not ripen until mid-September. At each harvest, tomatoes were sorted into "marketable" and "unmarketable" categories. Any fruits damaged by splitting, disease, insects, rodents or weather were considered unmarketable. Natural cat-facing on heirlooms or small dry cracks due to rapid growth were still considered marketable. Total weight and number of marketable tomatoes were recorded for each plot, as were total weight of unmarketable tomatoes and causes of damage. Perfectly ripe tomatoes were put aside for flavor evaluation and flavor components analysis. Disease ratings were taken three times during the season in each location.

Quality

Acidity is measured as titrateable acidity and converted to citric acid (CA) equivalents, as this is the principal organic acid in tomatoes. Soluble sugars are measured in ˚Brix. ˚Brix and CA were evaluated on all tomato plots from West Madison Agricultural Research Station twice during the growing season, and separately on each sample used for flavor evaluation. Tomatoes were frozen over night and then thawed to extract the juice for both analyses. ˚Brix levels were tested using a digital refractometer. Acid content by volume was measured using an automated titrator. The pH was also measured for each tomato juice sample, though it was of lesser interest than titrateable acidity, since the latter measures acidity by volume, thereby giving a more accurate indication of how acid is perceived as a flavor.

Tomato varieties were first evaluated by members of the research staff after a simple training exercise to allow the recognition and scoring of different flavor attributes. These included sweetness, acidity, saltiness, bitterness and umami. Color and texture were also rated by staff. A mixed model analysis of variance was used to analyze data from this tasting to determine which factors were most important in differentiating varieties. Using the variety means from the ANOVA, principal component analysis (PCA) was used to visualize the relationship among varieties using their entire flavor profile. These results were used to select a subset of varieties to be evaluated by participating chefs.

Chefs participated in a similarity-based method of descriptive analysis known as "Projective Mapping." There is a quantitative component based on the distance samples are placed from each other and a qualitative descriptive component. Chefs independently tasted each sample and place the sam-

ples on the mapping sheet according to their perception of similarity and dissimilarity. Once placed, chefs wrote the words they associated with a variety's flavor and texture directly on the map. Analysis of the chef tasting data is done using Multiple Factor Analysis (MFA) to produce a consensus map of how chefs view the different varieties. After completing the mapping exercise, chefs evaluate the varieties again, this time from a hedonic perspective. Questions like: "Would you buy this for your restaurant?" "How would you use this?" and "What is the best trait of this variety?" helped assess the chef's preferences.

Results

Production

The greatest difference was between tomatoes grown in the open-field and those in the hoop house, with variety being a significant but lower in magnitude effect. The market category (heirloom parentage, crosses between heirloom and modern varieties, modern large slicers and modern small slicers) did not have a significant effect on yield or disease resistance, suggesting that the perception that heirloom tomatoes are lower yielding and more disease prone may not hold for all varieties in this category, and that there is more variation within these market categories than between them.

In the 2014 preliminary trials, marketable yield was 20% greater in the hoop house; in 2015, marketable yield was 45% higher in the hoop house; and, in 2016, marketable yield was over two times higher in the hoop house, primarily due to greater disease in the field, including septoria, early blight, bacterial speck (in 2015) and extremely rainy conditions (in 2016). Varieties showed some differences in susceptibility to septoria and early blight, the two major foliar diseases, but these differences were much smaller than the effect of the management system (hoop house versus open field).

Quality

Citric acid content did not differ significantly between high tunnel and field production, while ˚Brix was higher on average in the hoop house. Varietal differences were significant, and contributed more to total variation in sugars and acidity than management. The ratio of CA:˚Brix was correlated with perceived flavor intensity, with lower ratios being more intense flavor. This could potentially be used as a screening tool to help choose a subset of varieties most likely to have good flavor for further evaluation by a panel. Modern large slicers had the highest ratio of citric acid to Brix, meaning that they were likely to have the lowest flavor intensity. The varieties with heirloom parentage were a similar size to the modern large slicers but had ratios more similar to modern small slicers and crosses of heirlooms and modern varieties. This is expected, as many tasters perceived the heirloom parentage, small slicers and crosses (which tended to be smaller in size), as having good flavor intensity.

Preference was strongly correlated to perceived flavor intensity and less correlated to individual flavor components. Chefs identified several breeding lines as having very good flavor, better than the heirlooms, with sweet-acid flavor profiles. For more savory (umami) tomatoes, heirlooms were still the best. More work needs to be done to get the classic savory tomato flavor into new breeding lines with better resistance to cracking and foliar diseases in organic systems.

Conclusions

Many of the favorite tomatoes for flavor were crosses between modern and heirloom variety selections from heirloom x heirloom variety crosses that had been selected for both performance and flavor. This is promising for breeding efforts to combine exceptional flavor with other traits of importance to growers as it suggests that by paying attention to flavor we can avoid compromising it when selecting for disease resistance or productivity and that these two important traits are not intrinsically a trade-off.

While the varieties in the on-station trials for this project have remained constant due to the need for multiple year comparisons, we have received new breeding lines from several independent, university and seed company breeders based on results from the first years of trials and farmer evaluation and feedback. These lines are currently in screening trials at the research station and the best ones will move to on-farm trials if funding allows. In the first couple years, our screening trials had a wide range of quality and production traits, but we have seen a shift in varieties that breeders are contributing, with an increase in both quality and adaptation to the Upper Midwest. We have used trial information to also identify potential parental varieties, particularly from heirloom backgrounds, for developing new varieties with quality and productivity in organic systems in the Upper Midwest.

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Crop Planning for Small-scale Wholesale Organic Seed Production

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Planning is an important step in the seed production process that can help ensure the farm's success and minimize risk. The crop planning process for our wholesale seed business here at Chickadee Farm begins with our income goal and sales plan and then uses yield data, crop and microclimate experience, and crop rotation principles to create a planting plan that meets the needs and goals of the farm.

Each year, we begin our planning by setting net and gross income goals for the farm based on personal goals, our experience and a sense of our farm's production capacity. Our farm's capacity depends on the size and quality of our labor force, the efficiency of our infrastructure and the systems we employ. We are constantly striving to increase our capacity through improving our farm systems, investing in tools that address production bottlenecks and recruiting the best employees possible. Beyond a sense of our farms' production capacity in terms of acres and pounds, we also assess our farm's capacity in terms of the type and quantity of species and varieties. We need to determine what species grow successfully commercially for us based on our climate, pest pressures and the potential for crossing with related wild species. We need to determine what species produce well here, how many varieties of each species we can grow based on its isolation needs, and what scale of each species/variety we can effectively and profitably manage with our labor and toolset. This underpins the conversations with our customers and retail seed companies, whom we solicit production contracts from. As we receive proposals and requests, we evaluate each crop/variety for several factors:

1. If it is a species that we can only grow one of, does the proposed production amount maximize our capacity? For example, if we were offered two contracts for a crop where we only have one isolation, with one for 50 lbs. and one for 500 lbs., we would take the larger proposal as long as we felt comfortable with our capacity to produce it.
2. Is the variety a good variety to grow? Does it yield seed well? Is it a robust variety? What level of roguing will it need? What special needs does it have?
3. Is the stock seed disease-free?
4. Is the price offered a fair price? As varieties of the same species often vary widely in their seed yields, this can be a difficult question to answer for new varieties, even if you know your cost of production. Often, for varieties where past yield information is non-existent, the best you can do is speculate based on average yields for that species. Price is often negotiable and is based on an open conversation between producer and buyer.
5. If the above questions are satisfied, does the species/variety fit into the overall farm plan that seeks to balance crops for seasonal labor needs, crop rotation needs and other farm management objectives?

Once contracts are agreed to and the number and quantity of crops is known, a detailed crop plan can then be created that includes planting dates, amount of bed feet to plant and location in the fields. In addition, field prep dates and amendment needs can also be determined from this info.

Planting dates are based on experience with the microclimate and the desire to get crops in early while minimizing risk or stress. Giving your crops the longest season possible ensures timely ripening but we don't push too hard to be extra early. Depending on the crop, the cost of extra labor, transplants, plowing before perfect conditions, and other factors is usually not worth the 2-3 weeks we might gain, especially if we have enough time in the normal season.

Deciding on the amount to plant is based on our previous yields for either that variety or the species average. We often add a 10-25% buffer (depending on species) to mitigate roguing and production risks and ensure we meet contract amounts. We always round up to fill beds as well. If we decide to try a new species, we'll consider it an experiment and limit our production to a small plot so that if it fails, the impact is minimal. Most often, we grow new species as a speculative crop rather than take a contract, as we don't want a potential failure to negatively impact our customers. For new species, we'll turn to Knott's Vegetable handbook and other seed growers for seed yield data.

Basic crop rotation principles, isolation requirements and soil characteristics then guide the placement of each crop on the farm.

What makes much of this planning possible is keeping detailed records from previous years. Records of yields per bed or acre, planting and harvest dates (which determine days to maturity), crop placement, pest and disease pressures, and reflections on crop needs and farm capacities and efficiencies, all help inform a more efficient and productive farm in the future. This motivates us to maintain the best records we can. Besides our traditional notebook to spreadsheet process, we have recently been using time-stamped pictures taken with a phone for much of our temporary in-field record keeping. We then have a visual record of most farm activities to help finalize and complete our overall record keeping later on.

Crop planning and record keeping has been an important factor in our farm's growth and success and we wish you the best in planning your next season!

Crop Planning for Organic Seed Growers

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Here are the examples Dan will be using during the presentation.

1. Set Your Goals

Profit Target:	$30 000
+Expense limit:	$30 000
=Gross Sales:	$60 000

2. Develop your Marketing Plan
   a. Divide your gross sales between your marketing outlets

Market Garden:	$32 000
+Wholesale seed:	$2 000
+Online Store:	$16 000
+Seed Racks:	$10 000
=Gross Sales	$60 000

   b. Convert retail seed sale targets into harvest targets
      i. Determine total packet numbers
         1. (Assuming $4 for retail pack & $2 for rack pack)
         2. Online Store: $16 000 sales / $4 per pack = 4000 packs
         3. Seed Rack: $10 000 sales / $2 per pack = 5000 packs
      ii. Allocate packet number targets to varieties

variety	Direct packs	Rack packs	Total packs	# years supply	Safety Factor	g/pack	Target kg	Target lbs
Cherokee Purple Tomato	100	200	300	3	1.3	0.2	0.23	**0.11**
Provider Bean	200	400	600	2	1.3	20	31.20	**14.18**
Mizuna	50	50	100	2	1.3	2	0.52	**0.24**

   c. Convert wholesale seed sale targets into harvest targets

Variety	$ / lb	lbs	Total Value
Cherokee Purple Tomato	300	2	**600**
Provider Bean	10	100	**1000**
Mizuna	40	10	**400**
Total			**2000**

d. Combine harvest targets

Variety	Retail Lbs	Wholesale Lbs	Target Lbs
Cherokee Purple Tomato	0.11	2	**2.11**
Provider Bean	14.18	100	**114.18**
Mizuna	0.24	10	**10.24**

3. Crop Planning

a. Yield Projections

Crop	lbs / acre	lbs / 100bedft
Amaranths	900	10.3
Beans	1500	17.2
Brassicas (Rapa, Juncea, Arugula)	900	10.3
Corn	1500	17.2
Cucumbers	200	2.3
Eggplants	150	1.7
Peas	1300	14.9
Pepper	150	1.7
Squash (Summer & Winter)	500	5.7
Tomato	200	2.3

b. How much area to plant?

Target lbs x safety factor / yield = # beds or acres

Variety	Target Lbs	lbs / 100ft bed	Safety Factor	# 100ft beds
Cherokee Purple Tomato	2.11	2.3	1.2	1.1
Provider Bean	114.18	17.2	1.2	8.0
Mizuna	10.24	10.3	1.2	1.2

c. Crop Rotation

Year	Group	Crops	Planting
1	Frost Sensitive Crops	Brassica, Peas, Lettuce, others	First week May
2	Cover Crop		
3	Tender Crops	Solanaceae, Cucurbits, Beans, others	First week June
4	Cover Crop		

Growing Strong Seed the Biodynamic Way

Thea Maria Carlson, Biodynamic Association; Beth Corymb and Nathan Corymb, Meadowlark Hearth; Jim Fullmer, Demeter USA; Marjory House, biodynamic farmer/consultant with SERO Biodynamic Seed

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Organic and biodynamic production are both rooted in ecological agriculture and a whole systems approach. Biodynamic agriculture incorporates additional practices and principles to enhance the health and vitality of the farm and the seed crops. Biodynamic practices help plants develop in a healthy and balanced way, access the full spectrum of nutrients they need, and become more resilient to pests, diseases, and extreme climate conditions. Demand for Demeter certified Biodynamic seed is growing among both seed companies and farmers due to the unique quality and vitality of biodynamic seeds.

Core Biodynamic Principles and Practices

Biodynamics is a holistic, ecological, and ethical approach to farming, gardening, food, and nutrition. Biodynamics is based on the work of philosopher and scientist Dr. Rudolf Steiner, and has been developed through the collaboration of many farmers and researchers since 1924. Around the world, biodynamics is alive in thousands of thriving gardens, farms, vineyards, ranches, and orchards. The principles and practices of biodynamics can be applied anywhere food is grown, with thoughtful adaptation to scale, landscape, climate, and culture.

Each biodynamic farm is an integrated, whole, living organism. This organism is made up of many interdependent elements: fields, forests, plants, animals, soils, compost, and people. Biodynamic farmers and gardeners work to nurture and harmonize these elements, managing them in a holistic and dynamic way to support the health and vitality of the whole. Biodynamic farms work to bring crops and livestock together into healthy symbiotic relationships, so that the plants feed the animals and the animals feed the plants, supporting and balancing each other. Biodynamic plants are grown in the ground in living soil, which provides a quality of health and nutrition not possible with chemical fertilizers or hydroponic growing. Biodynamic farms aspire to generate their own fertility through integrating animals, cover cropping, crop rotation, and composting.

On-farm fertility is further enhanced through composting manure and crop residues, which transforms and returns nutrients to the farm organism in an optimal form. Biodynamic compost is enhanced and enlivened through the use of six preparations made from yarrow, chamomile, stinging nettle, oak bark, dandelion, and valerian. A small quantity of each preparation is added to the compost pile just after it is built, and again after it is turned. Biodynamic preparations strengthen the quality of the compost by stabilizing nitrogen and other nutrients, multiplying microbial diversity, and bringing more sensitivity to the composting process. Biodynamic compost helps attune the soil to the whole farm organism while increasing soil life and stable organic matter. Biodynamic compost also brings more carbon into the living realm, helping to restore balance to the climate. In addition to the compost preparations, several biodynamic preparations are applied as potentized liquid sprays to nurture the health of the farm and garden. Together, the biodynamic spray and compost preparations help plants develop in a healthy and

balanced way, access the full spectrum of nutrients they need, and become more resilient to pests, diseases, and extreme climate conditions.

Growing Biodynamic Seed

An essential aspect of biodynamic seed is that it arises out of a whole farm organism with the intact biodiversity essential to develop, maintain, and reproduce. This means a dynamic interaction of a variety of plants and animals in the fertility cycle. The seed is maintained and used on the farm generation after generation. Thus it develops within the context of all the other living organisms and environmental influences that make up this unique farm organism. This exposes it to a natural selection process that adapts it to the particular life, place, and practices of the biodynamic farm.

The cultural context is of equal importance. Cultural selection is the essential process through which agricultural cultivars arise. The skill, taste, and preference of the farmer in doing seed selection guide the ongoing dynamic development of the cultivar. The farmer in turn is shaped and guided by the wider culture they inhabit, the food culture they grew up in or have chosen, and the markets, people, and populations they feed. Like the food they produce, the seed from that particular biodynamic farm individuality becomes something special, unique, with its own "terroir." The subtle dynamic interaction of phenotype and genotype within the farm organism over time are part of what makes a seed biodynamic.

Biodynamic seed selection tries not to work so much with a fixed type, but with dynamic living process of development and change. Integrity and stability of type are also essential. Needed are both the polar dynamics of stability and maintenance on the one hand, and change, adaption, and creativity on the other hand. The context of the farm, its cultural practices, needs, and practical and financial constraints demand reliability and predictability, as do the people and markets that the seed serves.

Biodynamic Certification

Demeter Biodynamic® certification dates back to 1927 in Europe and currently is a unique international collaboration active in 54 countries worldwide. Over 5,000 farms encompassing more than 400,000 acres are certified around the globe. The base Demeter Standard for certification is evolved annually based on an international, democratic process. Demeter USA administers and evolves the US Demeter Standard for Biodynamic farms and products in the United States from this base.

There are seven foundational principles which form the basis of US Demeter Biodynamic certification:

1. Biological diversity
2. Generating fertility on farm
3. Disease, insect and weed control generated out of the living dynamics of the farm
4. Use of the biodynamic preparations
5. Water and waterway conservation
6. Livestock integration
7. Gentle post-harvest handling

All seven principles are intimately and biologically interwoven, aiming for a farm that functions as a living organism in its own right. The aim is to have inputs needed for production arise out of the living dynamics of the farm rather than having to be imported from the outside. From a whole farm perspective, self-regulation is a goal.

In the USA the USDA National Organic Program (NOP) Farm Standard forms the base of the Demeter Standard, so Demeter Biodynamic Certification encompasses organic and goes further in several ways. Incorporating the principles listed above, the Demeter Biodynamic Farm Standard requires that the whole farm, and not just a specific crop, is certified; crops and livestock are integrated and animals are treated humanely; imported fertility is kept to a minimum; the biodynamic preparations are regularly applied; at least 50% of livestock feed is grown on the farm; at least 10% of the total farm acreage is set aside for biodiversity; and the farm upholds standards of social responsibility. Both conventional and organic farms have successfully converted to becoming certified biodynamic.

Market Opportunities for Biodynamic Seed

The organic retail market is showing sustained (even increasing) growth, with $47 billion in sales in 2016, and growth exceeding 8%, while food sales have only gone up 0.8%. As consumers become more aware of issues surrounding food sources and food supply chains, they also become educated in methods of food production. Organic certification of products gives consumers a level of trust that the products they are consuming meet a level of standard not held by "conventional" products. However, with the dilution of the term "organic," which is now used to sell everything from makeup to children's toys, there are consumers who want more out of their products, and want to be assured that the businesses they support are held to the highest standards when it comes to their practices. The biodynamic market has gained traction in the last few years, primarily through certification of vineyards and wineries, and the support and sale of biodynamic products in Whole Foods Market nationwide. Research firms have projected that in ten years, there will be thousands of biodynamic products on store shelves. Demeter certification gives consumers the security that what they are purchasing is held to the highest standard currently available for environmental and sustainability practices. Because there are very few Demeter certified biodynamic seed companies, the demand for this greatly outweighs the supply. There is not nearly enough biodynamic seed available to North American farmers. We hope that more seed growers will incorporate biodynamic practices and certification, and that more and more biodynamic farmers will grow seed on their farms. The unique qualities of biodynamic seed have much to offer for the future of agriculture.

For Further Information

More information on biodynamic agriculture and certification is available at www.biodynamics.com and www.demeter-usa.org.

Challenges and Opportunities with Seed Production in Enclosures

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Seed is most often produced in the expansive outdoor environment. However, structures such as greenhouses and mesh tents can be used as isolation structures for research, breeding, variety segregation, and environmental control of seed crops. Caged seed production using isolation structures presents several challenges and fun opportunities, including choosing structure design, set-up and maintenance, pest and pollinator control, and economic considerations.

Research in Enclosures

Isolation structures are extremely valuable research tools. Screened net cages and mesh bags are used to ensure pollinator exclusion and controlled pollen exchange for many types of crosses and seed increases, including multiplication and production of inbred parent lines, single plant crosses, strain crosses, self-pollinations, and increasing open-pollinated varieties and breeding populations. Multiple unique lines of the same or compatible species crops may be planted in the open field and isolated by means of covering plants with netting or cages before flowering occurs. This method is most appropriate for insect-pollinated, cross-pollinating crops with the introduction of pollinators, such as bees or flies. Although caged seed production is possible for wind pollinated crops, it is significantly more challenging compared to insect pollinated crops, as the density of mesh required to contain pollen restricts both light and air flow.

In British Columbia, small-scale farmers are currently engaged in a participatory research project with the University of Manitoba, FarmFolk CityFolk, and the Bauta Family Initiative on Canadian Seed Security to explore the use of isolation structures for growing carrot (*Daucus carota*) seed. While carrot seed crops perform well in BC's coastal climate, the overwhelming presence of Queens Anne's lace (*Daucus carota var.* carota), which readily cross-pollinates with domesticated carrots, makes carrot seed production extremely difficult. This research project is exploring several aspects of caged seed production, including crop population management, pollinator rearing and management, and economic analysis for small-scale carrot seed production.

In Washington State, Organic Seed Alliance (OSA) is also challenged by the ubiquitous presence of Queen Anne's lace in their endeavors to produce carrot seed as part of the CIOA (Carrot Improvement for Organic Agriculture) project, which is funded by USDA's Organic Research and Extension Initiative (OREI). OSA is using cages to make unique and new populations of carrots for breeding work, growing out selections to further breeding populations currently under development, and to increase seed of desirable populations to make them available for national trialing efforts. Experimenting with a range of small cage sizes from 25 to 200 square feet, OSA has also done multiple species seed production, combining Brassica and flower production in the same cages with carrots.

Structure Designs and Considerations

Cages can vary greatly in size depending on the scale of your operation, typically ranging from several to thousands of square feet. Cages can also host multiple crop species within a single cage as long as they are not biologically compatible. Cage design and integrity can be crucial to the success of your seed production efforts. There are very few companies that produce pollination structures and thus they are often made on the farm. One reliable source for pre-fabricated cages is Redwood Empire Awning (http://www.redwoodempireawning.com/agricultural-projects/), a company that manufactures custom pollination cages to fit your specific needs. The kind of mesh used for cage construction must be able to exclude any kind of pollinating insect, as well as contain any pollinators introduced into the cage. A 20x20 mesh is needed to exclude flies and bees, while a 52x52 mesh is required to exclude aphids. When choosing a cage cover or netting it is important to consider what pollinators you will want to use (flies, bees, bumblebees), as well as any beneficial insects you might want to contain over the course of the season.

Mesh cage fabrics also come in different colors, most commonly green and tan. There has been some speculation that tan cages do not heat up as quickly as the darker colored green mesh cages and hence provide a cooler atmosphere, which is an especially important consideration if bees are going to be used inside the cage.

Cages are commonly built in two design styles – rectangular and quonset. The quonset style cage design has less wear points since it has fewer hard angles and is therefore more durable from season to season. In areas of high wind or when cages are expected to last multiple seasons, it is recommended to use a quonset style cage to increase cage longevity. With a quonset style cage, there is a sacrifice of some walkable space within the cage due to the side-wall angles, so if you are growing tall flowering crops or plan on monitoring or roguing your crop extensively throughout the flowering and fruiting period, you may want to consider a rectangular design.

Photo 1: Rectangle cages allow more space for taller crops but can also have a shorter life span than quonset stytle cages.

Cage integrity is critical to keeping your seed increase(s) pure. The introduction of only a few outside pollen sources via insect can contaminate your entire production with no noticeable effects until the next generation is grown out. Cages need to be accessed throughout the growing season for monitoring the crop and pollinators; roguing the line, variety, or population; and for cultivating, fertilizing, pest control, and any other additional crop maintenance. It is prudent to include two entrances in your cage design, one on each end, especially if using a zippered entryway. The reason for this is that if one zipper fails, you can seal off that entrance while still having another convenient entrance for accessing the cage. The faster you can enter and exit the cage, the less chance you have of inadvertently introducing unwanted pollen sources or allowing insects to fly in or out. For this reason, a zippered entryway is recommended over a folded and fastened approach. While the zipper is often one of the first places to

fail on a cage, it is a nice convenience throughout the course of a season. It is prudent to double stitch and reinforce zippers and seams during initial cage construction to lessen the chance of tears and splitting down the road.

The bottom edges of the cage netting should be substantial (I recommend a minimum of 2 feet) to allow for securing/burying the edges beneath the soil. If cage bottoms fly up, the integrity of your seed production can be ruined in a very short period of time. Points of wear, such as corners and bottom edges, can be reinforced with heavy duty vinyl to ensure they stand up to the wear and tear of use over multiple seasons. Lastly, cages should be inspected at erection as well as regularly throughout the season to ensure that any holes that develop in the mesh netting are immediately repaired. Holes can be mended with a sewing needle and thread and extra mesh fabric, or in a pinch with heavy duty duct tape. I have found a heavy-duty, curved needle is especially useful for this task.

Single plant crosses or single plant self-pollinations can be achieved in much the same way as caged seed production, only on a smaller scale. "Bagged" cage increases involve caging only one or two plants in order to make a specific cross or a self-pollination. In this instance, species that are amenable to natural self-pollination or those that employ fly pollination are most appropriate. Typically, wooden or bamboo stakes are driven into the soil next to the plant and used to secure a mesh bag around the plant's flowering parts. Fly larvae can be added by untying the bags and allowing the flies to crawl up out of their container and into the pollination bag. Pollination bags can be removed once flowering is complete to allow for unhindered development of the seed crop.

Pollinators for Enclosed Structures

Pollinator management in isolation cages is critical to ensuring effective pollination and subsequent seed set. Cross-pollinated crops often rely on insects for pollination, thus insects will need to be introduced to the isolation structure to ensure pollination takes place. While bees are often the first insects that come to mind when one thinks of pollinators, flies are also very good pollinators and are easy to rear and maintain.

Bees as Pollinators

Using honeybees can be challenging, expensive, and hazardous in small cages. Even in larger cages, the stress to honeybees causes high mortality as they need ample pollen and nectar to stay healthy. Nuke hives (small starter hives) are generally best for caged pollination and it is recommended to work with a beekeeper to place them within your cage(s). It is best to keep the bees in the cage only as long as necessary for the pollination of the crop as it is somewhat stressful for a hive of bees to have only a single floral food source. To this end, careful observation should be employed to determine the convergence of the opening of female flowers and the availability of pollen from the male flowers. The more time a pollinator is in the cage, the less healthy and less productive they become. It is best to enter cages in the morning or early evening when the bees are least active to minimize the risk of being stung or disturbing pollination activity.

On the other hand, bumblebees are excellent pollinators for caged production and are not as vulnerable as a colony of honeybees. They are especially effective in cages with large flowered crops such as squash. Even so, protective clothing is recommended. Bumblebees will defend their hive and sting

when in a confined area. You should also consider the possibility of imported viruses affecting native bee populations before using bumblebees in your area.

Bumblebees are smart and are very adept at escaping the enclosure. Fortunately, if Queen Anne's lace is not flowering and there are no other carrot seed crops nearby, you can open the enclosure in the evening to let the bumblebees back into the enclosure when they return to their hive. If you are early to the enclosure, as the bumblebees are starting to be active, you can assess the enclosure for bee escape routes, and correct the issue. Bumblebee hives are expensive (over $200/hive) and our experience in BC is that the pollination from bumblebees was also not as effective as flies.

Flies as Pollinators

Flies are effective pollinators in cages and can be purchased as pupae (see http://forkedtreeranch.-com/) or reared on site. Purchasing fly pupae multiple times throughout the season can become expensive and in Canada particularly can be challenging as pupae are shipped from the US and sometimes hatch en route. From our experience in BC, rearing flies on site is easy and involves just a few steps:

1. Begin fly rearing 2-3 weeks before pollinators will be needed to have sufficient time for flies to complete their lifecycle and build up an abundant population in the enclosure for complete pollination at the time of flowering.

Photo 2: Step One: Attracting flies. Here we are using salmon to lure flies into the tote for egg laying (clear totes are best as they allow you to see how many flies are coming and going and keep track of the egg and larvae development).

2. Set out a clear tote with a lid on it containing a few inches of soil in the bottom with some fresh meat sitting on top (the smellier the better). The meat attracts flies that will then lay eggs directly on the meat. Drill holes in the tote to allow flies to get into the bin and the hatched maggots to get out and pupate in the soil once the bin is moved into the pollination enclosure. Place the bin in an outdoor location where fly populations are high, such as close to compost piles or standing water. Flies are less active on colder days and may not easily be attracted to the meat if the weather is cool. Leave the meat sit out for several hours and monitor for fly activity

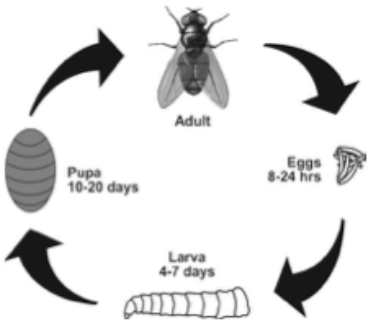

Photo 3: Blue Bottle Fly lifecycle – it takes approximately two to four weeks to complete a full cycle.

3. Once the meat has been adequately populated with eggs, move the tote into the enclosure and remove the lid. Any flies trapped in the tote are available to begin pollinating immediately, while the maggots (larva) will move into the soil below the tote or within the tote to pupate. Be sure you don't have any compatible wild relative plants flowering nearby or have any compatible flowering crops on your farm if you are going to be moving wild captured flies into your cages. Depending on how long the tote was set out for fly capture and how much egg laying activity there was flies should begin to emerge within a week or so. Step 1

should be repeated in one-week intervals for one to two more weeks, adding the egg populated meat to the cage once a week.

4. Once flies start to emerge they need to be sustained with a reliable source of water. You can achieve this by placing the lid of the tote under a drip line in an "empty" spot within the enclosure (we placed it where our carrot stecklings did not emerge). Place small piles of rocks in the lid to give the flies a safe place to land and access the water.

Photo 4: Tote lid with a drip line laid across it to create a water source for sustaining fly populations

This method of fly rearing proved to be very effective for carrot seed growers in BC in 2017, producing an impressive population of flies which was sustained throughout the flowering period of the crop.

Economics of Small-Scale Seed Production in Isolation Structures

At all scales of production, it is important to consider both the cost of the enclosure and required setup and maintenance time when determining the production costs of a seed crop. For example, carrot seed production in an enclosure at the UBC Farm in 2017 had the following costs: prefabricated 10′ x 20′ structure (from Redwood Empire Awning); the total cost of the enclosure — when amortized over 20 years (assumed lifetime of the cage) — was $298.00/year. The cost of producing the seed crop (including seed conditioning) in this 200-square foot space was $209.00, for a total production cost of $507.00. This production yielded 2000g (4.5 lbs.) of seed from 72 carrot stecklings at 18″ spacing. Total labor hours for this crop was between 12-14 hours.

The value of this crop on the market will depend on the producer's ability to market and sell the crop, or on pre-arranged production contract(s). Calculating the approximate sale of this seed crop at two different price points gives this crop a top market value of approximately $965, and if sold at wholesale prices, as low as $370. Therefore, we have found that the use of isolation structures for economically viable small-scale seed production may be contingent on the producer's ability to sell the seed at market price(s) rather than at a wholesale price.

Why Seed Companies Drop Beloved Varieties

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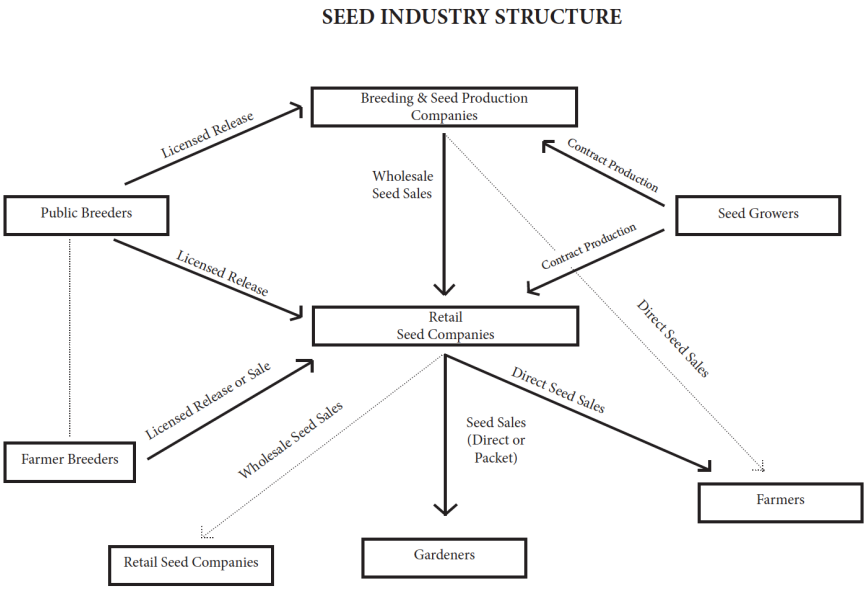
Recent drops of beloved varieties for organic growers have heightened the conversation of why seed companies choose to discontinue varieties that seem to be popular and successful. This can be particularly frustrating when growers have learned to produce the variety dependably on their farm, and have developed markets for those varieties. The reasons why varieties are discontinued are diverse and can include challenges with seed production (i.e., weak parent lines that are slow to mature or susceptible to disease, pollination issues, low seed yields, weed seed contamination, or seed borne diseases); sales volumes; and inventory management. Breeding companies are continually developing new varieties with better flavor profiles, improved yield potential, disease resistances, as well as more reliable seed vigor and production. Retail seed companies are constantly trialing new varieties, making comparisons with their current assortment, and selecting varieties to carry based on their customer base. The natural evolution of the vegetable industry trends toward constant innovation, financial sustainability, and adaptability to the market trends. Stagnation, or lack of progress, makes it difficult for seed companies to compete, and also makes it more difficult for growers to meet the growing consumer demand for sustainably grown produce.

The seed industry functions as a complex set of interactions among breeding companies, retail seed distributors, seed growers, public and independent breeders, farmers, and gardeners (see diagram below). Development of useful varieties by breeding companies is a cyclical process that requires multiple steps, including selection of useful traits, extensive trialing to determine variety performance, sales and marketing analysis of the variety value, seed production capacity, and farmer/gardener feedback. The goal is to constantly improve the selection of varieties available, yet challenges along the way can derail this process. Even after a variety has become commercially available, multiple factors can lead to its discontinuation. For example, spinach varieties tend to have a very short commercial lifespan, as the evolution of the downy mildew pathogen (*Perinospora farinose f. sp. spinaciae*) typically outpaces the varieties being developed. Once the pathogen has evolved to overcome the current resistances, the variety is no longer viable in the large spinach production regions of California, and secondary markets are usually not sufficient to sustain the varieties economically. Seed production can also cause multiple challenges. In the case of organic pepper production, common seed borne pathogens are not easily controlled with organic methods, leading to consistently low germination rates. In addition, conventional techniques to enhance nicking (the synchrony in flowering of both parent lines) and reduce seed shattering are not approved for organic production, which leads to lower yields. Issues can also arise during the cleaning and conditioning phase, as is the case with kale varieties such as Redbor. Seed production economics plays a critical role, because in the end, the variety must make money for the company that is producing it. In the case of supersweet and synergistic sweet corn varieties, often the inbred parent lines require such detailed attention to get adequate yields that the organic seed production costs become astronomical. Sometimes the specific variety traits required by growers shift, causing a variety to become obsolete outside of the primary market, as was the case with Nelson carrot. In other instances, the variety consists of older genetics and has been replaced by improved disease resistances and quality traits.

From a retail seed company perspective (i.e., seed dealer), often a supplier (i.e., seed breeder) will drop a variety, causing the retailer to review and replace it with similar varieties in the trade. The goal is always to find something better, or at least equal, when a drop occurs. Notification from a supplier of a "drop" can be years in advance (preferred!) or can occur via a quick email after a confirmed contract and the retail catalog has gone to press (less desirable!). The sooner a retailer knows about a drop, the sooner they can pivot to a good back-up that has either already been identified or begin a trial regimen to fill the gap. Occasionally, a supplier can become unreliable (price, quantity, quality, delivery, sales interactions), which can impact market adoption or a retailer's willingness to offer their varieties. It is rare that a retailer will drop a supplier completely because of such issues, but they may focus on carrying only a few varieties from that supplier. Conversely, a supplier can also choose to drop a retail company as a vendor or restrict sales for various reasons (e.g., minimum buys of quantity and/or dollar volume, payment concerns, sales interactions, or geographic restrictions). Finally, a political or moral stance may force retailers to reduce reliance on or to even drop a supplier completely.



Given this complex landscape, what is a farmer to do? Grower participation in the variety development process is critical to both ensure that the grower's preferences are incorporated into new varieties as well as to keep growers at the cutting edge of the most appropriate varieties for their systems. Recognizing that all varieties have a lifecycle, and that at some point beloved varieties may no longer be available, is a necessary reality. Growers can inform retailers that there is something better in the market that should be added or offered instead of a current variety. Customers also inform retail companies directly of the acceptance of a new variety by the measure of sales. When what was projected to be a potential winning replacement variety does not resonate, the retail company must reassess: Is there something else in the marketplace that is better? Was the variety adequately described in the catalog? Is price or some other factor limiting adoption? Was the timing of introduction not right? The best growers have a relationship with their seed suppliers, always trial new varieties, and give constructive feedback on what is working and what is not. With this model, growers are actively involved in the development process and hopefully can minimize the negative effects of dropped varieties.

Microbial Hitchhikers on Seed: Friend or Foe?

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Abstract

During their lifetime, plants are colonized by a diverse assortment of microorganisms. Some of these microbes can be transferred to a plant's progeny via colonization of seed surfaces and/or internal tissues. These seed-borne microbes can be pathogens, negatively affecting plant and even human health, while others may be beneficial, helping plants acquire nutrients and withstand biotic and abiotic stress. This workshop will provide an overview of how microbes are transmitted via seed, along with practical approaches to prevent transmission of harmful plant and human pathogens. Today, we will discuss the possible role of seeds as reservoirs of disease. Along the way, we will also consider other microbes that may survive in seeds from human pathogens to beneficial organisms. Finally, we will discuss how to discourage pathogen survival in seeds and encourage the "good guys."

Introduction

Recent studies have provided evidence that plants are colonized by an abundant and diverse assortment of microorganisms that include bacteria, fungi, archaea, and viruses. Consequently, the concept of what constitutes a plant has been redefined and plants are now perceived as a "metaorganism" or "holobiont," and the dynamic community of microbes interacting with plants is referred to as its "microbiome." Some of these microbes can be transferred to a plant's progeny via seed. The total abundance of microbes that may be present on individual seeds still remains unclear, though it has been estimated that bacteria alone can be as high at 10^8 CFU/g seed (Truyens et al., 2015). Because plant pathogens are the best-studied seed-borne microbes, and they can negatively affect plant germination and productivity, they will be used here as examples to illustrate how microbes are transmitted via seed.

The discovery of a disease in a vegetable field is bound to cause a grower to wonder why and how the disease got there. Of course, there are many answers. The organism that causes the disease, the pathogen, may have arrived by wind, water, pollinators, tools, or crop debris from last year, to name just a few methods of pathogen dispersal. How can pathogens hijack seeds? In general, there are two methods that disease-causing microbes can get into or on seeds.

Many vegetable diseases can cause lesions on the outside of fruit. Consider bacterial spot of tomato or anthracnose of watermelon. Each lesion is packed full of pathogenic propagules. When the fruit is opened to save seed, it is possible that the pathogens will adhere to the surface of the seed. Imagine a large operation where seed are extracted from many fruit. Tomatoes, for example, may be added whole to containers where seed is separated from pulp and skin. If lesions occur on the surface of seed the pathogen may end up surviving on the surface of the tomato seed. In some cases, bacteria may even end up inside the seed.

It is also possible for pathogens to end up in seeds of a fruit with no lesions on the surface. Some pathogens are systemic in the plant, meaning the pathogen can move within the plant. For example, let's consider Fusarium wilt of tomato. The Fusarium pathogen survives in the soil. When the fungus encounters a tomato root, it may be able to force itself into the root. While the fungus doesn't cause a rot of the root, the fungus may form spores that can easily travel in the vascular tissue of the tomato plant. Along with blocking the vascular tissue and causing wilt, the spores may also travel along the vascular tissue into the seeds. Diseases that cause symptoms on flowers may also result in pathogens inside seeds.

Table 1. Examples of plant pathogens that can be transferred via seed (Koike, et al., 2007)

Disease	Host	Pathogen	Symptoms	Location of pathogen on seed
		Wet seed harvest		
Bacterial spot	Tomato	*Xanthomonas* spp.	Scabby lesions on fruit	External
Bacterial canker	Tomato	*Clavibacter michiganense*	Bird's-eye spot lesions on fruit	External and internal
Anthracnose	Tomato, watermelon	*Colletotrichum* spp.	Sunken lesions on fruit	External
Fusarium wilt	Tomato, watermelon etc.	Fusarium spp.	Wilt, vascular discoloration	Internal
		Dry seed harvest		
Black rot	Cabbage etc.	*Xanthomonas campestris*	V-shaped lesions on leaves, dark vascular tissue.	Internal
Alternaria leaf blight	Carrot	*Alternaria dauci*	Angular lesions on leaves, flowers	Internal and external
Bean common mosaic virus	Common bean	BCMV	Mosaic mottle, stunting	Internal
Halo blight	Common bean	*Pseudomonas syringae* pv. *phaseolicola*	Necrotic lesions w/ yellow "halo" on leaves & pods	Internal and external

Enteric pathogens (i.e., *E. coli*, *Salmonella, Listeria*), which can cause gastrointestinal illness and even death in humans, can also be transmitted via seed in the same manner as plant pathogens (Hoagland et al., in press). These so-called "food-borne pathogens" have been isolated on seed from a wide variety of crops, including lettuce and tomato, but are generally considered most problematic in sprouts (alfalfa, mung bean and radish). This is because even very small initial populations on contaminated seed can grow to high numbers during sprout production due to high relative temperatures and humidity, and

the presence of nutrient rich plant root exudates that support rapid multiplication. While the presence of enteric pathogens on seeds is rare, the consequences can be severe and thus factors that can affect the transmission of these microbes should be considered during seed production.

Recent studies have provided evidence that many other microbes can be transmitted via seed, which could positively affect the germination, establishment and productivity of plants. The best studied of these "beneficial" seed-borne microbes are *Epichlöe* species in tall fescue (Saikkonen et al., 2016). The presence of these vertically transmitted endophytes was discovered because of their potential to produce alkaloids that are toxic to grazing livestock. Efforts to eradicate these microbes from tall fescue seed indicated that they markedly affect tall fescue fitness. Consequently, research is now underway to identify and cultivate *Epichlöe* species that can promote tall fescue growth without producing these alkaloids.

Managing seed-borne microbes

Individuals who purchase seed should be aware of what diseases may be seed borne in what crops. Check with your supplier to see if the seed is tested for seed borne diseases. Crops produced in a certified seed system will generally be inspected for certain seed borne diseases. Purchase seed that has tested negative for the disease. However, it is only possible to test a portion of the seed (the test is destructive). Although it is unlikely, seed that was not tested may be contaminated by the pathogen. In addition, it is possible for the disease to enter your field through another route, such as last year's crop debris.

If you purchase transplants that someone else has grown, then it is possible for the disease to come in on transplants. If you grow the transplants, carefully sanitize the greenhouse before use; transplant trays and tools should be clean and sanitized. Carefully inspect transplants as they are growing. Send any suspect samples to a plant disease diagnostic laboratory.

The seed production environment can have a large effect on seed sanitation. In general, seed produced in the arid intermountain region of the U.S. will have very low risk of transmitting seed borne fungi and bacteria compared to the more humid regions of the eastern U.S. Production with drip or furrow irrigation rather than overhead sprinkler irrigation will also mitigate risk of seed borne transmission.

Growers who save their own seed have the advantage of controlling all the steps from seed saving to harvest of the resulting crop. However, the grower who saves seed must understand the risks. Here are some suggestions for seed savers:

- Do not save seed from fruit of a field where a seed borne disease exists. At the very least, do not save seed from a plant or fruit with a seed borne disease.
- Carefully sanitize the outside of each fruit before it is cut open. Depending on the fruit, it may be appropriate to ferment the seed in its own juices for a period time.
- It may be appropriate to treat the seed either with heat or with a substance such as chlorine. Heat treating has to be done carefully to avoid lowering the germination rate. Properly done, heat treating will dramatically reduce the number of pathogens inside and outside of seed. A treatment such as chlorine or similar oxidizing agent will, if done properly, reduce the

pathogens on the outside of the seed (Gatch, 2016). Be sure to determine if the seed treatments are allowed in your organic certification scheme.

Implementing good agricultural practices (GAPs) (Coleman and Maynard, 2014) is essential to reducing the chances that seed will become contaminated with enteric pathogens. Growers are also advised to avoid seed that has been damaged by insects, pathogens, or seed conditioning, as these seeds can be more difficult to sanitize. If you suspect seed is contaminated, or you are producing sprouts, you may also want to consider treating your seed. The same chemical and heat treatments described above can also help reduce survival of enteric pathogens (Hoagland et al., in press).

Recent studies highlighting the abundance and diversity of beneficial microbes that may be hitching a ride with seed has generated much interest in learning how to manage these microbes and several research projects are underway. For example, it may be possible to enhance colonization of beneficial microbes by inoculating flowers during seed development. Unfortunately, this research is still in its infancy and specific practices to ensure colonization and survival of these beneficial microbes have not yet been defined. In the meantime, growers should consider implementing management practices that improve soil health and keep their plants healthy during seed production to help encourage transmission of beneficial microbes in their seed.

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Organic Hybrid Production in the U.S. — Methods and Case Studies

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The ability to produce hybrid crops organically in North America is important for a safe, reliable, and responsible seed supply that is in keeping with the principles of the organic movement. Currently, much hybrid seed is either not available from an organic source or is produced overseas in countries with low wages and few environmental regulations. Hybrid seed crop production offers seed growers an opportunity to produce a high value product and to work with many of the new varieties developed by plant breeders.

Before embarking on hybrid seed production it is important to understand the process and specific challenges involved in different crop species. Compared to open-pollinated (OP) varieties, several additional steps must occur in F1-hybrid seed production that are not required for OPs. For example, two separate parental lines must be grown and then crossed together for seed production. The parental line that is being used as the seed parent must be prevented from pollinating itself and pollen from the pollinator parent must be delivered to the flowers of the seed parent. The strategies for accomplishing these simple but important steps are specific to the floral biology of the crop. By examining case studies in three different crops (tomato, squash, and corn), we aim to understand several of these strategies in detail and to highlight examples of successful organic hybrid seed productions in the United States.

In the last 30 years, the use of tomato hybrids in North America has become commonplace and is at least partially responsible for increased farm productivity. Hybrid breeding has allowed for the combining of many disease resistances into a single, highly uniform variety. However, one of the points of contention with the use of tomato hybrids is that virtually all tomato hybrids are produced outside of the U.S. and Canada, due to the high labor costs of hand pollination. Hence the question arises, is domestic hybrid tomato seed production a viable business strategy? Two U.S.-based seed companies, EarthWork Seeds and Nipomo Native Seeds, have been working together to breed, test, produce, market, and sell organic hybrid tomato seed to major North American seed vendors. This collaborative venture has produced a successful outcome with significant prospects for the future.

The emphasis during this collaborative project focused on first developing a new hybrid tomato with good disease resistance, field performance, and flavor. Product development took advantage of trialing networks and cooperative feedback. Seed production was mostly about labor – providing a living wage in California, while keeping a very tight rein on excesses. Female plants were grown in 15 liter pots and males grown in 5 liter pots in greenhouses, with attention paid to specific pruning techniques to produce the maximum number of flowers. Tomatoes are hermaphroditic, with both sexual parts present in the same flower. Hand emasculations of unopened flowers were made daily in the morning and immediately pollinated. A second pollination was performed 24 hours later. For hand-pollinations made outdoors, where insects are present, it was necessary to cover the pistils to avoid contamination by unwanted pollen. Seed marketing and sales relied on a strong, interactive network of retail distributors to ultimately bring seeds to thousands of end users. The upshot of this venture demonstrates that produc-

tion of organic, hand-pollinated hybrid tomato seed in North America can be profitable using a modest budget.

In the case of squash, hybrid seed production in North America can also be profitable but has its own set of unique, crop-specific challenges. Managing the two parent lines shares similar aspects to hybrid production in other crops, but does require some specialized techniques due to being insect pollinated and monecious with separate female and male flowers on the same plant. Emasculating the female parent line (i.e., removal of male flowers) is the most common way to control the pollination and great care needs to be taken in the timing, emasculation technique, weather and pollinator interactions. These factors can lead to issues that either increase labor costs or cause crop failure, but there are a lot of tricks for success which are not described in any book and can only be learned from practice or study with an experienced producer. Other production techniques involving more labor-intensive hand pollinations are not always practical on a large scale and use of non-organic hormonal sprays to chemically emasculate the female line is not an option with organic production. It is worth noting, however, that conventional growers have a lot more experience with hybrid production so those of us in the organic industry can learn a lot from them.

High Mowing Organic Seeds has produced hybrid squash seed profitably for over 10 years. We have found it to be an important part of our farm and it gives us the ability to offer unique varieties to our customers that we might not be able to otherwise offer. The majority of the pollination work takes place mid-season, often before the harvest of any other seed crops. The pollination labor needs per acre can be as much as 60 hours per week for over a month, so growers need to plan ahead for this. This crop also requires daily scanning and diligent work during the pollination window of 2-6 weeks. It is also worth noting that any hybrid production requires the additional genetic maintenance of both parent lines and a final hybridity test to verify the uniformity of the final seed crop. These are extra tasks and expenses not needed with OP squash seed production and can sometimes present more challenges even after all the work has been done to produce the hybrid crop. With well selected and organically adapted parent lines and careful timing, this can be a profitable seed crop for small to medium organic producers with the potential to net $20,000+ per acre.

The production of organic hybrid corn seed also poses some interesting opportunities for growers in North America, but there are both production and agronomic issues that need to be carefully addressed to make high quality seed. One of the basic requirements is that in the mainstream corn seed industry a large-scale infrastructure is required to husk, dry, shell, clean and bag the quantities of corn seed on the scale that is necessary to enter the market. Gro Alliance is the nation's largest independent contract seed company which had been established since the 1940s and currently produces corn and soybean seed for many customers throughout the world. In making the decision to enter into this new potential organic market, the company chose to build a certified organic corn cleaning and conditioning line in Cuba City, Wisconsin, to set the foundation for producing the high quality and crucial purity of seed necessary to help build this industry.

On an agronomic level, the basic challenge is that seed corn is grown using inbred corn seed lines which are extremely different than most other crops that growers are familiar with. The plants are small, with extremely weak vigor and mostly absent of canopy to shade out weeds. Seed corn is a high-maintenance crop in terms of fertility and weed control. Seed corn production has traditionally been done using specialized equipment and skills for planting, de-tasseling and harvest with established

dedicated seed corn growers. Essentially, the commercial seed industry is a highly conventional agriculture system with no certified organic ground and little incentive among growers to transition. In order to build the organic industry, instead of working with conventional corn seed growers, we are choosing to partner with certified organic growers and work closely with them to develop and create the skills necessary to produce high quality corn using their farm's own equipment and specific organic agricultural systems. Our goal is to experiment, learn and share the knowledge to build an organic seed corn growers network to support this nascent industry.

Seed growers and companies interested in organic hybrid production will learn many valuable market and production insights from these three distinct case studies of new or alternative models for seed production being explored in this country.

Private Sector Solutions to Increasing Organic Seed Usage

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Despite tremendous strides in the past decade to increase the availability of organic seed and planting stock, more work and innovative solutions are needed. Examples of ongoing efforts include improving the regulatory framework to strengthen and clarify organic seed use requirements, education, plant breeding, seed research investments, and development of organic seed search databases and other data collection tools. The National Organic Standards Board (NOSB) has worked on organic seed policies since its formation in 1992. While this has enabled an organic seed industry to rise and fulfill the need for high-quality organic seed since implementation of the USDA organic rule in 2002, the organic community has repeatedly noted that progress toward full adoption of organically grown seed in organic systems is too slow, and limitations of the current regulatory framework are partly to blame.

USDA organic regulations allow the use of non-organic seed when equivalent organic varieties are not "commercially available" in the appropriate quality, quantity or form. However, the procedures for determining commercial availability of organic seeds and planting stock have been inconsistently interpreted and applied. In 2005 and 2008, NOSB made recommendations to the National Organic Program (NOP) on the need for guidance on how to interpret and enforce the organic seed requirements. Through a notice and public comment process, NOP published the *Guidance on Seeds, Annual Seedlings, and Planting Stock in Organic Crop Production* in 2013 (NOP 5029). The guidance adopted many of the NOSB recommendations but not all of them. As a result, many stakeholders felt that the guidance did not go far enough nor reflect the progress made in the organic seed sector since the regulations were written.

In response to requests from organic stakeholders, NOSB in 2016 started soliciting public comment on ways the organic seed guidance could and should be strengthened to achieve full compliance with the seed requirements in the organic standards under §205.204 (a). One of the main criticisms of the current seed guidance is that it fails to provide a framework for what continuous improvement looks like and how to achieve it in the context of seed. NOP has communicated to NOSB and the organic sector that regulatory modifications are needed to verify "continuous improvement." As a result, in the spring of 2017, NOSB released a recommendation for a "first-ever" change to the organic seed section of the organic regulations to require certified operators to demonstrate increased organic seed usage over time. NOSB also recommended several revisions to NOP's existing guidance (NOP 5029) for seeds, annual seedlings and planting stock used in organic crop production. The proposal was tabled for further work at the fall 2017 NOSB meeting. Now, NOSB is planning to bring back a revised version for public comment prior to the spring 2018 NOSB meeting.

The time and resources invested over the past decade on organic regulatory and policy solutions to strengthen the use of organic seed have been immense, but progress has been arguably slow. Although work on the regulatory front is important and needs to continue, the organic sector must also embrace the challenges we face under the current White House Administration. In short, regulatory solutions are not getting any easier and we must not overlook the critical role of the private sector. In spite of the

regulatory climate, we see steady progress in the organic seed trade, and avenues for growth are all around us. Organic breeders are heralded as "taste makers," organic seed quality is in a constant upward climb, and large players have made continual commitment and investment. These and other positive factors are encouraging profitable adoption of organic seed by growers, and support remains strong with home gardeners.

In this workshop, we hope to share and highlight private seed success stories, comparing the past with today, while bearing in mind the efforts ahead. While participants will receive an overview of current seed policy discussions within NOSB, including a close look at the 2017 NOSB proposal to update the organic seed regulation, the session will emphasize private sector solutions for increasing organic seed sourcing by further developing the relationship between processors, organic growers, seed providers and certifiers.

A panel of experts, including an organic policy expert, an organic seed provider, an organic producer and processor and an organic certifier will share perspectives on the challenges of growing, developing, sourcing and regulating organic seed to meet the diverse regional and global demands of organic production. The discussion will examine opportunities for certified operations that contract with growers and mandate specific types of seed or planting stock and the prospect of launching an industry-led "organic seed pledge." Much of the workshop will be interactive, where audience members will be encouraged to ask questions and share perspectives, experiences and solutions to inform ongoing policy discussions, private sector solutions and resources focused on strengthening organic seed systems.

Best Practices for Intellectual Property Rights in the Public Plant Breeding Sector

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Plant variety protection under the terms of the Plant Variety Protection Act (PVPA), plant patents under the Plant Patent Act, and licenses that permit breeding under terms such as the code of ethics for sharing germplasm, are all supported forms of intellectual property protection. Sometimes the utility patent may be the best choice to ensure that a cultivar is commercialized, but when used, utility patents and licensing agreements with terms restricting the availability of cultivars developed with public funds for breeding must be avoided. The original wheat workers code of ethics is at the end of this paper.

Farmers must be allowed to save seed of cultivars developed by the public sector

Farmers' right to save seed are a key component of the U.S. International Treaty on Plant Genetic Resources obligations, and must be included in any release of cultivars developed with public funding. Under the PVPA, farmers are permitted to save seed in the quantities needed for their own planting.

Public sector breeders deserve a fair return for their efforts

The release of cultivars under mechanisms that allow for continued breeding and seed saving does not preclude the generation of revenue for breeding programs. Many cultivars generate revenue under licensing agreements without any federal form of intellectual property protection. Because of the unique nature of cultivar development and commercialization, cultivar release has historically been handled by *sui generis* systems at public universities. However, the revenue generated from licenses of public cultivars at most universities have now been rolled into a standard intellectual property protection and royalty distribution system in recent years to the detriment of cultivar innovation.

It may be helpful to think of cultivar development and release as a similar activity to that of a university-sponsored start-up. Many universities are now supporting faculty entrepreneurial activity by allowing faculty-led start-up companies to use a portion of the revenue generated from their activities to build and maintain the company. Since university-owned intellectual property is the primary asset of such start-ups, if the university collected all the revenue from inventions and did not allow the start-up to re-invest it in their business, they would quickly cease to exist. This can partly explain the decline in public cultivar development programs as the historic revenue stream from licenses that supported continued innovation and maintenance of breeding programs has been diverted to other university uses.

For best practices, following successful models at the University of Florida and elsewhere, at least half of revenue generated through the licensing of publicly developed cultivars should be returned to the program that developed the cultivars for use specifically in continuing to devel-

op new cultivars. However, it is not reasonable to expect public plant breeding programs to serve farmers in their states and the broader public good while generating all of their own operating expenses, as private sector programs are expected to do. Plant breeding and cultivar development in the public interest often includes target traits that are not being developed in the private sector because it is difficult to financially recover the investment through seed sales or licensing fees. Examples include the development of perennial crops for conservation, developing crops for regional and state needs that do not represent large national seed markets and developing crops with consumer benefits, such as increased nutritional content. As public universities exist to serve the public interest, other methods of public funding of cultivar development must also be explored.

Professional standard of ethics for sharing germplasm

This is slightly modified from the Wheat Workers Code of Ethics for Distribution of Germplasm 1976 and 1994.

1. The originating breeder, institution, or company has certain rights to the unreleased material. These rights are not waived with the distribution of seeds or plant material but remain with the originator.
2. The recipient of unreleased seeds or plant material shall make no secondary distributions of the germplasm without the permission of the owner/breeder.
3. The owner/breeder in distributing unreleased seeds or other propagating material, grants permission for use (1) in tests under the recipient's control, and (2) as a parent for making crosses from which selections will be made. All other uses, including those below, require the written approval of the owner/breeder.
    (a) Testing in regional or international nurseries;
    (b) Increase and release as a cultivar;
    (c) Reselection from within the stock;
    (d) Use as a parent of a commercial F1 hybrid, synthetic, or multiline cultivar;
    (e) Use as a recurrent parent in backcrossing;
    (f) Mutation breeding; selection of somaclonal variants; or use as a recipient parent for asexual gene transfer, including gene transfer using molecular genetic techniques;
    (g) Genotyping with molecular markers.
4. Plant materials of this nature entered in crop cultivar trials shall not be used for seed increase. Reasonable precautions to ensure retention or recovery of plant materials at harvest shall be taken.
5. Under exceptional circumstances, the distributor of germplasm stocks may impose additional restrictions on use or may waiver any of the above.

Policy recommendations

In August 2016, the University of Wisconsin-Madison hosted an Intellectual Property Rights for Public Plant Breeding Summit in conjunction with the National Association of Plant Breeders' annual meeting in Raleigh, North Carolina. The best practices referenced above were discussed with participants at this event. Policy recommendations were also considered, including increasing capacity funding through the authorization of the Farm Bill and appropriations. Dis-

cussions also focused on increasing base funding for public cultivar programs and better availability, and targeting of, competitive grants. Specific recommendations include the following.

2018 Farm Bill requests should:

- Require a minimum of $50 million per year in total National Institute of Food and Agriculture research funding be directed to public cultivar development.
- Reauthorize the National Genetic Resources Program with the explicit charge of establishing a national strategic germplasm assessment and utilization plan.
- Expand the duties of the National Genetic Resources Advisory Council (NGRAC) to provide guidance to the Secretary on USDA funding for public cultivar development, the state of "in-field" crop genetic diversity, and resources needed to sustain the next generation of public cultivar developers.
- Ensure that all cultivars and animal breeds developed with public funds protect the rights of farmers to save seeds and the rights of breeders to share and improve such germplasm.

Agricultural appropriations requests should:

- Increase Hatch, Evans-Allen and all other such land grant university capacity funds by 10% with the explicit charge of supporting public cultivar development and the training and ongoing retention of the next generation of public cultivar developers.
- Increase funding for the National Genetic Resources Program by 20% to address significant backlog of existing accessions.
- Increase the Agriculture and Food Research Initiative (AFRI) with the goal of reaching the full authorized level of $700 million by the end of the upcoming Farm Bill term.

To immediately support more public cultivar development, the USDA can:

- Develop a distinct program for public plant breeding research within the AFRI Foundation Program with a clear requirement for the development and release of public cultivars.
- Expand support for graduate student-led public plant and animal breeding research through AFRI, OREI, SCRI and other funding mechanisms for graduate and post-doctoral research, with a clear focus on public cultivar and breeds development.
- Encourage proposals for farmer-participatory, on-farm plant and animal breeding and cultivar/breeds evaluation to expedite the adoption of research innovations by industry.
- Establish a White House Office of Science and Technology Policy Liaison for Public Plant and Animal Breeding.
- Direct the USDA Research, Education and Extension Office (REEO) to coordinate public plant and animal breeding activities within and between REE agencies and in close coord nation with NGRAC to track and monitor progress toward the reinvigoration of public cultivar development.
- Establish a USDA agency-wide public cultivar and breeds advisory team that includes external stakeholders from the farm and public plant and animal breeding communities.
- Encourage the Secretary to convene regular stakeholder listening sessions to provide recommendations on national and regional priorities for pubic cultivar development and NIFA competitive grant programs.

Compatibility of New Breeding Techniques with Organic Systems

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Summary

Novel breeding techniques continue to be introduced, posing a challenge to organic agriculture. IFOAM-Organics International has proposed a set of measures to protect the integrity of organic food and farming systems. Criteria to differentiate between what is compatible and what should be excluded from organic cultivars and breeds are to be based upon the principles of organic agriculture, and the discussion should be transparent, inclusive, and informed. The positions that IFOAM has taken will require organizational and institutional efforts to implement them.

Introduction

With a growing understanding of genetics and biochemistry, new technologies continue to be developed that change the ability to develop new varieties. The rapid development and release of novel genomes is leading to an unprecedented amount of genetic disruption. These techniques continue to present organic agriculture with the challenge of determining which technologies are compatible with the Principles of Organic Agriculture: the principle of care—which incorporates the precautionary principle—and also the principles of health, fairness, and ecology (IFOAM 2005). These principles were all considered when excluding various genetic engineering technologies from organic agriculture. In accordance with the Precautionary Principle, proponents of new technologies, rather than the public, are responsible for showing that the resulting activities do not pose unacceptable risks of harm to human health or the environment (Wingspread Statement 1998).

Like all other organic standards throughout the world, the IFOAM Standards categorically prohibit the use of genetic engineering in organic food and farming systems (IFOAM 2014). The categorical exclusion of genetic engineering from organic food and farming systems has led to several unresolved issues. Every time a new technique emerges, the question arises as to whether it falls within the accepted definition of genetic engineering. Twenty years have passed since the USDA proposed allowing genetic engineering and receiving comments that overwhelming opposed inclusion of genetically modified organisms (GMOs) in the organic standards. Since that time, existing techniques that were previously accepted as compatible with organic principles and compliant with organic standards have been called into question.

IFOAM—Organics International is an internationally recognized non-governmental organization that has played a leading role in defining organic agriculture, establishing the principles that form the foundation of organic food and farming systems, and protecting the integrity of the organic standards. IFOAM took an unprecedented stand in opposition to the allowance of genetic engineering in organic standards, and has been regarded as a leading voice throughout the debate. IFOAM has constructed a detailed table that looks at different genetic engineering techniques and their compatibility with organic food and farming systems (IFOAM 2017a). Some techniques are clearly compatible with organic principles, and many are clearly excluded. There are some that have been accepted in the past without much understanding and discussion, and some of these techniques—such as cell fusion—may need to be phased out (IFOAM 2017c). There are other new ones that may at some point be considered compat-

ible, but at present, IFOAM advises getting more information with a broader open discussion among farmers and interested members of the public.

Organic Breeding

Innovations are needed for organic agriculture to advance and meet the growing demand. However, those innovations are required to take place in the context of the landmarks of organic agriculture (IFOAM 2017b), particularly the standards (IFOAM 2014). Organic breeding supports sustainable food security, food sovereignty, and the secure supply of plant, animal, and other agricultural products to supply animals' and peoples' nutritional needs. Genetic diversity is sustained and improved. Breeding techniques respect the reproductive system of the species or organism that is the subject of selection and improvement. Option value for future growing conditions are preserved. The IFOAM Position Paper categorically rejects patents on life forms, and supports access to and circulation of genetic resources. Priorities are adaptation to local conditions, nutritional quality, and the sustainable use of resources within the context of the dynamic equilibrium of the agro-ecosystem.

Some of the techniques that IFOAM considers to be acceptable or conditionally acceptable in organic breeding include bridge-crossing, composite cross populations, cytoplasmic male sterility (male sterility identified in nature or obtained by wide crosses), embryo rescue in plants, fast track breeding by single seed descent, generative propagation, hybrids based on mechanical emasculation, in-bred lines, inter-specific hybrids, marker-assisted selection, open pollination, ovary and embryo culture, proteomics/metabolomics, targeted crossing—both within and between species, targeting induced local lesions in genomes, transposons induced by physical stress, and vegetative propagation of cloned plants (IFOAM 2017a).

Many of these techniques are well established, and their ecological implications have a long record of safe application. IFOAM has identified a few techniques that may need to be phased out, such as induced mutation by radiation or chemical mutagenesis. In many cases, varieties and organisms selected from such populations have not been properly identified. IFOAM has called for the formation of regional action networks that will support their phase-out strategy.

New Techniques

As novel techniques of plant breeding are developed and commercialized, the organic sector needs to evaluate their technical, social, and institutional compatibility with the organic principles (Nuijten, Messmer, and Lammerts van Bueren 2017). IFOAM has determined that techniques such as Oligonucleotide Directed Mutagenesis (ODM), Zinc finger nuclease technology, CRISPR/Cas, Meganucleases, Cisgenesis, grafting on a transgene rootstock, agro-infiltration, RNA-dependent DNA methylation (RdDM), reverse breeding, and synthetic genomics are not compatible with organic farming and must not be used in organic breeding or organic production (IFOAM 2017a). The implications for the co-existence of organic agriculture and genetic engineering are far-reaching. The legal and regulatory framework needed to protect organic agriculture from excluded techniques requires clear and consistent legal definitions to be in place and regularly updated to accurately classify and regulate products derived from such novel techniques. A multi-stakeholder process is needed to develop a protocol that prevents the presence of such products in organic food and farming systems.

Information on these techniques and the organisms modified using them should be required from all developers. This would include information on the methods used to create the new genotype, the intended phenotypic characteristics, and identifiable genetic markers to enable detection, if available.

Developers and breeders should be required to declare whether a variety or breed complies with organic standards, or state that it is excluded.

IFOAM calls upon government agencies to enact and enforce regulations that will protect organic agriculture from the presence of excluded techniques and genetically modified organisms. As such, IFOAM supports the "polluter pays" principle. Organic farmers should not be the ones who bear the burden of analytical testing or the economic losses that result from the denial of organic status in places that have maximum thresholds, or rejection in the marketplace where such thresholds have not been established.

Greater resources should be directed at public breeding, and specifically the development of strains and breeding techniques that meet organic standards and the needs of the organic sector. The organic sector and relevant stakeholders should convene a review panel to evaluate new techniques. IFOAM proposes that a positive list of organic varieties and breeds should be constructed and maintained. Seed banks and animal conservation initiatives should be established and supported to conserve biodiversity and be insurance in cases of contamination or loss. Protection of biodiversity and rural livelihoods will need to be protected from the ongoing releases that result from these new technologies.

Conclusion

The organic sector is faced with a growing number of challenges from an unprecedented number of new biological technologies applied to plant breeding and other agricultural technologies. Transparency and an informed public are both required for these technologies to be evaluated. More information, by itself, does not necessarily lead to better informed decisions or appropriate outcomes. The process for making these decisions and implementing the outcomes needs to be inclusive, with adequate opportunities for discussion. It is up to the organic community to become informed, active, and engaged in establishing policies that will allow for innovation and the development of new cultivars suitable for organic production, while still protecting the integrity of organic food and farming systems.

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Continued Discussion in Europe on Breeding Techniques Suited for Organic Agriculture

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The intense discussion on breeding techniques was initiated by the emergence of genetic modification (GM) in the late '90s. The Dutch Ministry of Agriculture understood that the organic sector wanted to remain GM-free but also wanted to know whether other existing breeding techniques were acceptable for the organic sector. A framework was developed by the Louis Bolk Institute (LBI) and discussed during various national and international workshops. The framework included three categories of techniques: plant-based, cell (tissue)-based and DNA-based techniques. Techniques that were targeted at direct changes at DNA level were GM-related and not permitted in organic agriculture. The cell- or tissue-based techniques, such as embryo-rescue, were considered laboratory techniques involving artificial growing media that are not certified as organic and therefore not desirable but not prohibited by the public EU regulation for organic agriculture (Council Regulation (EC) No. 834/2007). Only the plant-based breeding and propagation techniques seemed appropriate.

The organic research institute FiBL in Switzerland recently published an updated version of their brochure on the evaluation of breeding techniques (FiBL 2015). That triggered an editor to launch a special issue of the journal Sustainability on the acceptance of novel breeding techniques. Researchers of the LBI and FiBL were jointly invited to write up the state-of-the-art in organic farming with respect to the acceptance of these new techniques (Nuijten et al. 2015). The existing framework is still helpful in assessing what is compatible with the organic principles, based on respecting the integrity of plants and not allowing direct interference at the DNA level. This means that all new breeding techniques, including cisgenesis and CRISPR-Cas, are not acceptable for organic agriculture.

In Europe, the so-called novel breeding techniques (NBTs) are officially considered GM techniques and only used in research. The public and political debate in Europe on the novel breeding techniques is still ongoing. Several times, the European Commission has postponed the decision to place the NBTs in a category of GM-related techniques exempted for GM-labeling, and the final outcome is not predictable. If these techniques will eventually fall in the exempted category then it will be a challenge for the organic sector to keep cultivars resulting from such breeding techniques out of the organic market. Transparency by breeders should be the base for such a strategy.

The organic sector has clear arguments to remain GM-free based on the IFOAM principles of health (respecting integrity of life), ecology (need for locally adapted cultivars) and fairness (no patenting on life, open access to genetic resources for breeders). As the techniques are new and still in an experimental phase and thus little is known on the consequences of applying such techniques, I think it also suits the organic sector not to be the first group to accept such techniques based on the IFOAM principle of care (precautionary principle).

The best thing the organic sector could do is to promote organically bred cultivars and to support organic plant breeders in distinguishing their cultivars in the market. Several European or-

ganizations are proactively engaged in supporting breeders that have bred a cultivar according to specific organic objectives and methods by launching a trademark Bioverita at the Biofach tradeshow in Neurenberg, Germany, in February 2018 (see https://bioverita.ch/en/).

Another positive impulse is the start of a four-year European project LIVESEED (2017 – 2021) to boost organic seed production and plant breeding across Europe with 35 partners and 14 linked partners in 18 countries with a total budget of 8 million euros (see https://www.liveseed.eu/). This project gives the organic sector in Europe the chance to speed up the use of organic seed and to develop breeding activities where gaps exist, and to initiate innovative, multi-actor approaches in developing new systems-based breeding strategies.

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So, I Bought Some Seed — What Can I Do With It? IP Ambiguity and Its Impact on Organic Seed Availability

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PROLOGUE: An organic variety is born, 1.0

'Sweet 100 F1' was a legendary tomato that earned its reputation during the 1980s. Alan 'Mushroom' Kapular, legendary organic breeder and seedsman and one of the principle founders at Seeds of Change, figured out that the F1 designation was a ruse. When he grew out the putative F2 seed every plant was identical. Having learned this, Seeds of Change put the variety in their catalog as 'Sweet 100 OP.' Shortly, they received a cease and desist letter from Peto Seeds ordering a stop to sales and declaring that there was no "OP Sweet 100." SOC responded that in fact there was no F1 Sweet 100…that the truth was out. Peto replied that in any case, "Sweet 100" was a trademark that SOC was not free to use. So the name was changed to 'Peacevine' and it is still produced organically and sold under this name.

Peto Seeds on the other hand was absorbed by seed consolidation in the mid-90s, and its name changed to Seminis in 1996. 'Sweet 100' became 'Sweet Million F1,' and you can still buy it.

From the beginning, a central challenge for the organic seed sector has been gaining access to new varieties for organic production. One of the missions at Wild Garden Seed has been to increase the availability of certified organic seed varieties for growers, and we've done that through breeding our own varieties on the farm, and by appropriating available commercial and heirloom seeds. In the early years of this mission, 20-odd years ago, the only seed company with national reach offering 100% organic seed was Seeds of Change. That catalog began the process of heirloom and commercial seed "organification" by organizing a cadre of organic growers to grow out varieties selected from seed catalogs and racks and pulled from personal collections. Mind you, there was no National Organic Program at the time and only a few states had implemented certification. There was no "organic seed requirement" for growers, and planters were allowed to use any seed to begin their organic production, even fungicide-treated seed. When the NOP "organic seed rule" was proposed, the organic community had its dissenters. Many veteran growers insisted that this was going too far, that the seed was irrelevant to the organic process, and especially that the requirement would relegate them to using inferior quality seed of inferior outdated varieties sold at high prices. At the time, some of this was true. The quality seed houses and breeding companies did not "do organics." Most of the seed catalog companies selling to organic growers were not certified themselves, and had no love for the idea that their inventory systems would need to be completely revamped in order to accommodate certified organic seed. One skeptical company owner was quoted as saying, "The companies don't want to sell it, and the growers don't want to buy it…so why are we doing this?!"

Organic seed growers had a lot to prove at the end of the 20th century, and not much to go on.

In 2002 the NOP organic seed requirement went into effect, albeit with a generous and persistent loophole allowing untreated conventional seed use when organic seed of adequate quality, volume, or kind was not available as organic. Wild Garden became a certified organic seed source. Other companies either certified wholly or bit the bullet and divided their inventories into separate organic and conventional sides. Higher up on the supply chain, the seed houses of Europe developed separate organic departments and organic breeding programs (e.g., Bejo) or purchased organic seed companies as outlets for their new organic programs (e.g., Enza Zaden/Vitalis). At Seeds of Change, growers had to become certified organic, not just sign an affidavit declaring themselves organic. This was the beginning of the certified organic seed industry. For some perspective of where we were at this point, Organic Seed Alliance wasn't yet even an idea. There was clearly an opportunity for organic growers to become the basis of a new organic production sector, but there was a lack of knowledge and there was a lack of new genetics available to an independent organic seed industry that would make it viable and competitive with conventional seed.

Knowledge was something we had within the community, and after 2002, seed growing and genetic improvement workshops began to be standard sections at regional organic grower conferences. John Navazio can be credited with raising consciousness about the intersection of genetic maintenance and improvement within the organic seed growing enterprise. Wild Garden Seed can take some credit for demonstrating that organic farmer-bred varieties can run with the heirlooms and commercial workhorses and earn a name for themselves. Appropriating heirlooms and old commercial standards to the "variety organification" process was straightforward, because these were well within the public domain and no one felt they owned them. But when new varieties were being considered for certified organic production, the organic community got its early education with intellectual property protection, and good manners.

PVP (Plant Variety Protected) varieties had vexed independent seed growers for some time. There was a lot of complaining among independent seedfolk dating to the '80s and '90s about not being able to grow and sell Sugarsnap peas until its PVP expired. Without a license from the PVP certificate holder, these varieties could not be made into certified organic seed for certified organic growers. Lettuce and other self-pollinated crops were heavily PVP'd throughout the '90s, and by the early 2000s almost any open-pollinated crop that could be made an F1 hybrid was an F1 hybrid, or would soon be. This was another method of intellectual property protection, since F1s could not be used to reproduce varieties. Because of a lack of varietal diversity, organic farmers who wanted to grow organic seeds were having a hard time not duplicating each other, which is to say, competing with each other rather than the conventional market. In the search for good commercial varieties to grow for the organic market we looked for PVP varieties that would soon expire, knowing that once the PVP was gone, the variety would disappear. That was the pattern. Any cross-pollinating OP variety was a good bet for organic production, because we knew it would soon be replaced by a hybrid. Thanks to this strategy for drafting varieties into organics, a lot of good varieties have been kept in production by organic growers that would otherwise have disappeared from the market.

Utility patents for lettuce first got my attention in 2008. Patenting began well before that, but I didn't see a patent number at the end of a lettuce description in a catalog until then. This seemed like a major escalation in the seed ownership game because patents connote ownership over all aspects of a plant—all its parts including pollen, and all its progeny, all its traits, indeed even over any information that may be derived from it through research. As someone who has spent my life breeding lettuce and

growing lettuce seed for sale, dodging PVPs and avoiding varieties with ® attached to their names, the prospect of utility patents on lettuce traits was daunting, but at least avoidable…if you knew what was patented.

Since 2008, patent notifications in catalogs have become more common, replacing PVP as a favored form of protection. This is significant because PVP allows for breeders and researchers to use the variety as a genetic resource, but patents do not. This precludes organic plant breeders from including important traits for disease, pest, and stress resistance, as well as critical modern traits for productivity and adaptation. This is a serious hindrance for bringing significant new varieties to the organic seed market, and as more patented varieties are introduced by industry, options for modern genetic improvements seem tangled. One begins to wonder if any modern variety can be brought into an independent breeding program for organic seed without someone laying claims against the final product. My opinion is that patent claims on natural traits are attempts to patent the work of nature, which in fact are discoveries, not creations. Discoveries are not patentable. But there are many conflicting opinions on these issues regarding patent rights and breeders' rights, natural traits of plants versus natural traits of humans, and more. Ambiguity.

There is another trend in seed ownership that is scarcely visible. Indeed, it's invisible unless you read the fine print in the Terms of Business section of the paperwork that accompanies a seed order, or possibly it's printed on a seed package, or it's at the bottom of a website menu. Here it is common enough to read that the seed accompanying this notice is for the singular purpose of producing a vegetative plant for personal consumption or sale to a consumer, followed by a lot of what's not to be done or grown or sold or published on account of this seed. One certainly may not use any trademarks associated with the seed, which presumably includes the name, except to promote the sale of the vegetative product. This is a contractual limitation on the use of the seed that you agree to by using the seed, apparently. I don't know how often these things get litigated, but I would love to hear the case. If this is not just boilerplate, if this kind of contract holds water, you may not grow Amish Paste tomatoes for seed if the seed packet tells you not to, despite Amish Paste clearly being in the public domain. Oregon State University (OSU) vegetable breeder Jim Myers, well versed in intellectual property law regarding seeds, has pointed out that this is in conflict with seed law that permits anyone to grow seeds that are in the public domain.

In 2017, this has become even more personal for me and my corporate persona, Wild Garden Seed. We sought out some new lettuce this year for the catalog. I bought a lettuce from a national catalog, enticed by its description. It was new to me. We grew this lettuce to seed and noted its good characteristics along the way. We only grew about a pound of seed and anticipated putting it in the catalog so our new offerings wouldn't look so inbred. I got as far as thinking about a price for it and even the description was written before I realized where this lettuce originated…that is to say, who had written the fine print (I didn't see) saying I should have not grown this variety to seed.

So there I sat in November, looking at this pound of seed that I had put considerable expense into growing, photographing, cleaning, and describing…wondering who this lettuce seed belonged to…and what I could do with it.

I have grown about 200 flower varieties over the past two years. Some are very old varieties, some are very new, but they are all new to me. I am a novice in flowers, a babe in the cutting garden. I have not

grown any trademarked or patented varieties that I know of. I avoid them. But after staring at that bag of lettuce, I began to wonder how many of those flowers have some kind of restriction on their reproduction? When I looked into it I found some seed sources had restrictions on reproduction written into their terms of doing business, and some did not. In some cases, finding the restricting conditions of sale was difficult. Are those names trademarked? How would I know? What is my responsibilities to find out versus an owner's responsibility to inform me of the ownership claims? Can a user of seed be held to a contract that is unseen and not agreed to? So much ambiguity.

When the Open Source Seed Initiative was finding its way to keep open source seeds from being patented or used to breed patented seeds, we explored "shrink wrapping" contracts to keep seeds free. The shrink wrap concept came from a software intellectual property (IP) protection model, wherein a user agrees to contractual restrictions regarding use merely by opening the package. The legal advice we received was that these enveloping contracts would not work for us, that every packet of seed would need seven pages of legalese attached for it to be binding on the seed recipient. Not a practical solution. This is why OSSI elected to go with a simple pledge to assert moral authority over those seeds, rather than attempt legal authority, in a bid to keep others from privatizing the genetic resource. Knowing this, I wonder how an invisible contract can keep anyone from reproducing seed they purchased or received second hand.

Considering all this, perhaps I could sell that lettuce without the breeding company having any legal satisfaction against Wild Garden Seed. Maybe the retail company that sold it to me would have some pain from the breeding company for not passing along restrictive language to customers. Maybe the company that sold it to me would blacklist me for violating terms I was not aware of. I doubt it. There's a lot of ambiguity here, and maybe that's how it's going to be until some violation is worth the cost of legal action so a court will get a chance to test these claims to ownership. But maybe that ambiguity is all it takes to keep competition at bay, which of course, is the real goal.

So what am I going to do with this lettuce seed? It will not be available through our catalog. Considering what I know about the breeder's wishes (having dug to the bottom of the fine print), it would be bad manners to sell the product of the breeder's work, and because the breeder offers it as an organic variety, I can see no ethical imperative to offer it as an organic choice. But I might give it away at a seed swap. If I can verify that it actually has no patent on it, I'll be tempted to breed with it. If its patent is a secret, I can't very well abide by it, can I? There's plenty of ambiguity to go around.

Are We Buying Seed or Are We Renting It for a One-time Use? Transparency on Intellectual Property Restrictions Between Wholesalers, Retailers and End Users

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As a seed merchant, I have always believed that I owe a duty of transparency to my customers, not only by describing each variety as accurately as possible, its faults as well as its virtues, but also by telling them exactly what it is they are buying. Today I wish to discuss a troubling issue for retail seed suppliers and for their seed customers: the use restrictions that are often attached to seed, but that some seed suppliers and their customers (third-party users) are probably unaware of.

A contract with one of Fedco's suppliers tipped me off that many varieties now come with restrictions to their use. I subsequently researched Fedco's more than 1,000 varietal offerings and found nine seed suppliers carrying intellectual property restrictions that affected more than 120 varieties in the catalog as well as a few others offering cultivars with Plant Variety Protection (PVP). These intellectual property (IP) restrictions manifest in various forms: they can be in contracts from the wholesaler to the retailer, through language on bag tags and invoices, or in the form of PVP and utility patents. (Fedco does not offer utility-patented varieties.) Bag tags are literally tags on bags that contain restrictive language that comes into force when the bags are opened.

In the case of PVP, the process is usually transparent. Most good seed catalogs identify the PVP varieties and somewhere in small print address the limitations in use that PVP conveys. PVP does not restrict growers from saving the seed of these varieties for their own use nor from using it for breeding. Utility patents, which carry comprehensive limitations on use of the seed, are less transparent in that some but not all catalogs and websites identify these varieties and their restrictions. Contracts and bag tags whose provisions apply to retailers but may or may not apply to third-party purchasers are not at all transparent in that they and the information contained in them are not customarily conveyed to the end users (gardeners and farmers) of the seed. Nothing in the variety descriptions warn these users that they are not buying full rights to the seed (as enumerated by OSSI in the Four Seed Freedoms: the freedom to save and grow seed for replanting or any other purpose; the freedom to share, trade or sell seed to others; the freedom to trial and study seed and to share and publish information about it; and the freedom to select or adapt the seed, make crosses with it, or to use it to breed new lines and varieties) but are instead purchasing a limited license to rent the seed for a one season use only.

Typical language in bag tags and contracts limits permission for use of the seeds to a single planting and strictly forbids using the seeds and any plant material from them for the purpose of repeated propagation. Often it will read "All Intellectual Property Rights remain with x. The customer shall not use the seeds for reproduction in any manner..."

Such intellectual property rights (IPR) limitations mean that ownership of the seed and of the intellectual property inherent therein remains with the original supplier and does not pass to the retailer or the end user. Neither the retailer nor the user in this transaction is buying the seed. The retailer is purchasing only a license to sell the use of the seed subject to certain conditions and limitations; the third party end user is not purchasing ownership but instead is renting the seed for a restricted one-time use.

Yet, if you peruse seed catalogs and websites you won't find any mention that these varieties are rentals and not sales. For many end users and some varieties this might not matter. First, many restricted varieties are F-1 hybrids that would not come true in the next generation. Second, only a small minority of seed users (especially of home gardeners) save seeds for replanting (and only for certain crops), and an even smaller group select among plants and seeds to try to improve the variety or use it as breeding material. However, the latest Organic Seed Alliance survey found that a majority of the growers surveyed save at least some of their own seeds and that on average these farmers fulfilled at least 20% of their own seed needs. The survey also indicated that many more would like to learn the seed arts and would consider becoming commercial seed growers. So the lack of transparency in these IPR restrictions is troubling in at least three ways: 1) that the restrictions, themselves, prevent growers who wish to from saving seed, selecting and improving these varieties; 2) that they may inhibit new would-be seed savers; and 3) that due to the lack of transparency, growers could be unknowingly violating IPR agreements, and in the worse-case scenario could find themselves in legal trouble as did those who allegedly violated Monsanto's bag tag restrictions.

The lack of transparency should also be troubling for retail seed purveyors. Do the contract, bag tag or invoice restrictions extend to third party users? It is not always clear. I asked six suppliers that very question with mixed results. While one answered "no" and another that growers and home gardeners were not restricted, only large-scale commercial propagation, three others answered in the affirmative, one of them a subsidiary of a larger corporation whom I did not query. One of these three went on to ask me, "If you are repackaging the seed, do you have any restrictive language on your packaging?" A second large supplier whom I did not query was the only one to include an affirmative duty clause on the part of the retailer in its contract to convey these restrictions to third party users and a clause making the retailer potentially liable if a third party user failed to comply, thereby implying a more than "yes" answer to my question. This could trouble retail seed houses for at least three reasons: 1) the lack of clarity as to whether the IPR agreement extends to third party users; 2) acting on an affirmative obligation to convey the restrictions might depress the retailer's sales on affected varieties; 3) retailers lack the resources to police third-party users and may be at risk if their obligation to wholesalers explicitly or implicitly conveys such responsibilities; and 4) where the wholesaler uses overly broad language on its documents this may have a chilling effect on seed saving if third-party users become aware of it, even if the wholesaler has no intentions of enforcing its IPR on mere seed savers. Such wholesalers may be trying to have the best of both worlds, using these instruments to discourage seed saving while at the same time being unwilling to risk consumer backlash.

In the face of such complications, I can see why the seed industry might prefer to ignore these issues and pretend there is no problem here. But given the growing intrusiveness of IP-restrictions and the sad history of farmers who came up against Monsanto, I believe this would be a very shortsighted approach. I would instead advocate for greater transparency in all of these relationships, both between wholesalers and retailers and between retailers and end users. Simple ways to achieve such transparency would be for wholesalers to be clear in their language on bag tags and contracts: do they restrict all third-party users, some third-party users or no third-party users? (Say what you mean and mean what you say.) And for retailers to identify on their websites and in their catalogs the restricted varieties and the nature of those restrictions that apply to third-party users. From way back when I was selling at farmers market to the present day offering seeds, my best customers have always been my most knowledgeable customers. I believe people have the right to know what they are buying and what they are not, and what obligations any agreements they make convey.

The Open Source Seed Initiative: Liberating Seeds From (All but One!) Use-Restrictions

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Background

The erosion of farmer sovereignty over seed—via corporate appropriation of plant genetic resources, growing monopoly power in the seed industry, the development of transgenic crops, and the global imposition of intellectual property rights (especially patents)—has become a pivotal issue for farmers the world over. Increasingly, the access of farmers and breeders to genetic material is subject to use-restrictions drawn from both intellectual property and contract law. In response, the Open Source Seed Initiative was created to "free the seed" from such use-restrictions. This is accomplished with a "copyleft" pledge attached to newly bred cultivars. Recipients or purchasers of OSSI-pledged seed are assured of the freedom to do whatever they wish with the seed, with one restriction: that they give that same freedom to anyone to whom they give or sell that seed or any of its derivatives or progeny.

Although revisions have further circumscribed their original rights, under the Plant Variety Protection Act farmers can still save and replant seed of protected varieties for their own use, and breeders can employ those materials for the production of new cultivars. However, neither a "farmer's exemption" nor a "research exemption" is available for material protected under U.S. utility patent law. The mutually reinforcing effects of concentration and patenting have had significant effects on both farmers and breeders: they cannot save, replant, share, sell, or breed with patented material without the permission of the patent holder.

Moreover, concentration in the seed industry has now proceeded so far that intellectual property arrangements need no longer even be the chief means for reducing the "freedom to operate" of farmers and breeders. Use-restrictions on seed are now most commonly applied and enforced via contract law. The mechanism for this is—for farmers—the "bag tag" or Technology Use Agreement (TUA) and—for breeders—the Materials Transfer Agreement (MTA). Both the TUA and the MTA are legal contracts which specify a wide variety of use-restrictions as a condition of acquiring the seed. While application and enforcement of patents and TUAs is notoriously visible in field crops such as maize, soy, and wheat, these arrangements are now being widely applied in the vegetable sector.

The Open Source Seed Initiative was created expressly to free the seed from these use-restrictions and to restore freedom to operate to farmers and breeders.

OSSI's Origins and Organization

The Open Source Seed Initiative (OSSI) was formally established in May 2012 at a meeting in Minneapolis, Minnesota. The twenty persons attending represented a wide variety of perspectives and interests—academics, plant breeders, the seed trade, farmers, indigenous people, the Global South—and shared a deep concern over the way in which intellectual property rights are

being used to enhance the power and control of a handful of companies over the seeds and farmers that feed the world. Further, the participants shared a commitment to creating a means for ensuring that the genes in at least some seed cannot be locked away from use by patents and other restrictive arrangements. The core strategy for achieving that goal is the dissemination and propagation of the OSSI pledge and of OSSI-pledged varieties, both of which preserve the rights of farmers, gardeners, and plant breeders to freely use, save, replant, and improve seed of OSSI-pledged material.

OSSI was incorporated in the State of Wisconsin in July 2014. It was granted federal tax exempt, 501(c)3, status in April 2015. It received trademarks for the OSSI logo in August 2015, and for "Open Source Seed Initiative" in January 2016. OSSI is managed by a nine person board of directors supported by an executive director. Together, this staff plans and implements education and outreach that promotes sharing rather than restricting access to plant germplasm, recognizes and supports the work of plant breeders of all kinds, and supports a diversified and decentralized seed industry.

The OSSI Pledge

The OSSI pledge was inspired by the free and open software movement that has provided alternatives to proprietary software. Since a formal license, while possible to develop, turned out to be impractical to use, OSSI created its pledge as a simpler and more functional tool. The OSSI pledge reads: "You have the freedom to use these OSSI-Pledged seeds in any way you choose. In return, you pledge not to restrict others' use of these seeds or their derivatives by patents or other means, and to include this Pledge with any transfer of these seeds or their derivatives."

This "copyleft" commitment ensures that the Pledge is transmitted with any further distribution of the seed or the seed of any new varieties or lines bred from it. The Pledge has both moral and legal force and is a guarantor of what OSSI regards as the Four Essential Seed Freedoms:

1. The freedom to save or grow seed for replanting or for any other purpose.
2. The freedom to share, trade, or sell seed to others.
3. The freedom to trial and study seed and to share or publish information about it.
4. The freedom to select or adapt the seed, make crosses with it, or use it to breed new lines and varieties.

OSSI refers to seed of OSSI-pledged varieties as "freed seed," rather than "free" seed to emphasize that OSSI-Pledged seed is freed with respect to use, but not necessarily free in price. OSSI accepts certain contracts or agreements to facilitate seed increase and/or provide benefit sharing to breeders**.** OSSI permits any contract or agreement for seed increase and/or benefit sharing for OSSI-pledged varieties in which the agreements on the use of the seeds are limited to the two contracting parties. OSSI does not accept arrangements in which there are restrictions on the seed that extend beyond the two contracting parties. Seed companies can pass no restrictions on to breeders or customers. From the point of view of breeders or customers, OSSI-pledged varieties must be unrestricted.

Operations

OSSI works to continuously enlarge the pool of crop varieties that are "OSSI-pledged," and so are freely available for use and improvement by farmers, gardeners and breeders without encumbrances. In addition, OSSI spreads information about and promotes the use of these varieties. OSSI recruits breeders (OSSI Variety Contributors) who formally commit to offering one or more of their cultivars only under the OSSI pledge. OSSI Seed Company Partners agree to sell at least one OSSI-pledged variety, to market the seed by labeling it with the OSSI logo and/or name, to acknowledge the breeder in variety descriptions, and to include the pledge and information about OSSI in their print and on-line catalogs. On the "Seeds" page of its website, OSSI provides a list of OSSI-pledged varieties with photos and descriptions. The list is searchable by crop, breeder, and seed source. Through its educational and outreach activities, OSSI creates awareness of the social value of purchasing "freed seed." Via its website and outreach materials, OSSI guides farmers and gardeners to its Seed Company Partners. For its Seed Company Partners, OSSI is thereby creating a niche market for ethically produced, "freed seed" analogous to the markets for "fair trade" and "organic" products.

While some public breeders have OSSI-pledged some varieties, it is notable that the great majority of OSSI-pledged cultivars have been contributed by "freelance" breeders. With diverse backgrounds and training, these independent, non-institutional breeders predominantly develop organic/sustainable cultivars adapted to local agronomic conditions or markets, and sell seed of their cultivars in relatively small quantities directly to farmers and gardeners or through small seed companies. What they have in common is a fierce commitment to keeping seed accessible. Moreover, they appear to be the ones most clearly positioned to benefit from OSSI. Pledging their cultivars to OSSI results in acknowledgment of their work, formal registration of their cultivars, and a measure of protection against unauthorized and unrecompensed multiplication and sale of their material—none of which they enjoy in the current system.

OSSI's portfolio currently includes over 380 OSSI-pledged cultivars contributed by 38 OSSI Variety Contributors. Seed of these varieties is available from 52 OSSI Seed Company Partners. OSSI's work has received extensive coverage in media outlets of all kinds.

International Cooperation

The issues that have stimulated the creation of OSSI are global in scope and significance. Colleagues all over the world have been excited and inspired by the potential of open source approaches to freeing the seed. OSSI has Variety Contributors and Seed Company Partners in Australia, Canada, Finland, Ireland, and the UK. However, socio-agro-legal-political environments vary considerably around the world. OSSI's deployment of open source seeds in the USA is facilitated by the fact that the USA places virtually no restrictions on breeding and subsequent sale of seed. In contrast, breeders and seed sellers in the European Union labor under the extremely restrictive regulations of the Common Catalog. These regulations forbid selling most seed that is not listed in the Catalog, and the requirements for listing are such that, practically speaking, farmers, gardeners, and small seed companies find it very difficult to breed and sell their own varieties. Most nations of the Global South are now being pressed to accept similarly restrictive IPR, phytosanitary, and certification rules. Despite such barriers, efforts to free the

seed are making gains globally. The German NGO, AGRECOL, has written an open source license adapted to EU conditions (see http://www.opensourceseeds.org/en/home). The Indian NGO, Centre for Sustainable Agriculture, has developed an open source license designed to complement the Indian Seed Law. The Dutch NGO, Hivos International, is working to introduce open source seed projects in East Africa (see https://www.hivos.org/focal-area/open-source-seed-systems). OSSI is cooperating with these initiatives and others to build an international platform for supporting open source, freed seed.

Contact

OSSI welcomes communication and commentary from interested parties. Visit our website at osseeds.org or contact us via e-mail at info@osseeds.org.

Protecting the Genetic Integrity of Organic Seed

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The USDA National Organic Program regulations do not allow the use of "excluded methods" in certified organic production. Excluded methods is the term used when referring to genetic engineering (GE). The USA is in the belly of the beast, where 94% of the soybeans, 92% of the corn, 94% of the cotton (cottonseed oil is a foodstuff derived from cotton), 75% of the Hawaiian papaya crop, 90% of the sugar beets and 90% of the canola is GE. Planting stock is not immune to genetic engineering, with the non-browning apple poised to be in the marketplace in a few years, as well as fish, pigs, and a wide variety of vegetables and fruits. Various traits are engineered into these crops, with herbicide resistance the main trait and the presence of insecticides in every speck of DNA within those plants the second most popular trait inserted into the genetic material of these patented and unique "life forms."

There is no testing required by the USDA organic regulations, either of seed nor crops, for the presence of unwanted GE materials. For many years farmers, who purchase and plant nonorganic seed due to the lack of organic seed commercial availability have needed to obtain non-GE affidavits if their seed is a type that has a GE equivalent in the marketplace. These affidavits have been accepted as proof by their organic certifiers that the seed is non-GE. Even if a seed or crop has been found to be "contaminated" with unwanted genetic material, technically it does not lose its organic certification status. Depending on the requirements of the ultimate buyer, and the integrity of the seller, some of these known contaminated seeds and crops are expected to make it into the organic production stream and ultimately the organic market.

In the raw crop marketplace, there is a "wild-west" attitude where some buyers are performing extensive and expensive testing and others perform more inexpensive tests, only periodically, or none at all. Some buyers do testing of grower supplied samples, semis when they are unloaded at the facility and of cleaned product before it is shipped out to the next customer. Others do not. This inconsistency in the marketplace, both for seed and for the final crop, leaves organic growers vulnerable to the whim of buyers as well as to genetic contamination that occurred from no fault of their own in the field, during transport or at the cleaning facility. The European Union, as well as other international and domestic buyers, have a tolerance limit, allowing some GE contamination (.9%) while still accepting the product as organic. There are no prescribed or consistent GE tolerance levels for U.S. organic production.

Most organic seed producers take protection of genetic integrity quite seriously. They monitor their custom growers, or their own facilities, when planning location, planting dates, pollination times for their crops in comparison to GE crops in the neighborhood, transportation and more. Even with this careful oversight, some corn seed breeders report almost 20% contamination of their organic corn seed with unwanted GE material. These seed breeders then destroy these lots of seed. They then need to raise the prices of the remaining organic corn seed to cover this loss, resulting in higher prices to farmers.

Since there is an allowance for the use of non-organic seed when organic seed cannot be found of an equivalent variety in the quality and quantity desired, this offers another risk to GE contamination of organic crops. If you start out with GE-contaminated seed, you multiply the amount you have once you have grown the crop. Non-organic seed producers do not perform the same due diligence in testing

and oversight to protect against GE contamination as organic seed breeders. Some may state in their non-GE affidavits that their assessment of non-GE presence is "to the best of their ability," since they are not actually testing to prove this statement as true.

The issue of maintaining the genetic integrity of organic and non-organic seed and planting stock grown on organic land and sold in the organic marketplace is complex with no easy answers. Organic seed and planting stock growers and the farmers who buy their products can be at odds, even though they are both seeking the same outcome of avoidance of GE whenever possible. Non-GE labeling, such as the non-GMO project, is not a guaranteed 100% GE-free, since the project has a .9% tolerance level allowed in foods for human consumption and a 5% allowance of GE contamination in livestock feeds whose final product would then be labeled as non-GMO or non-GE.

Tolerance levels can come with their own problems. How are these tested and by whom and where in the supply chain? Would a 100% GE-free standard in organic result in large regions of the U.S. not being able to grow organic crops, preventing growth of organic acres and commercial activity in this country? Could those that sell or buy the GE crops that are causing the contamination be assessed a fee to cover the losses caused by GE contamination? How could this be implemented?

This question of solving GE contamination in organic seed and crops does not have clear solutions, and might result in the unintended consequence of causing damage to the growth and integrity of organic agriculture as well as victimizing organic growers and seed breeders. On the other hand, growers and consumers feel contamination of organic seed and crops negatively affects the integrity of organic food.

This list of questions is by no means comprehensive, but is a starting point for discussion on possible options to address GE contamination at the seed level. This is a big topic, with all types of ideas and solutions encouraged!

1. Should the current situation of monitoring GE contamination remain as is?
2. Are there seed traits or production methods that could contribute to less GE contamination?
3. Should there be more information gathered to better understand the pervasiveness of GE contamination before we move towards addressing this issue? How could this be accomplished?
4. Should there be mandated testing of all seed (either or both organic and nonorganic) planted on organic land?
5. Should there be an approved list of tests, and or testing laboratories, for tracking the presence of GE in seed and/or crops?
6. Should there be an approved method of sampling for GE?
7. Should there be mandated training for those who are performing the sampling of the various lots?
8. How much of a seed or crop should be tested to provide confidence that the entire lot is GE free?
9. Once we know if a crop is GE or not, should there be a tolerance level? If yes, how much?
10. Should the organic community seek public monies to cover the cost of this testing?

11. Who pays for the loss of seed that can no longer be planted on organic ground, especially if there is no other market for this seed?

12. Should there be a tolerance level of GE contamination in organic seed? In organic food and feed?

13. Should different crops have the same percentage of GE tolerance?

14. Based upon the pervasiveness of GE contamination and the higher risk of movement of various crops' genetic material in the wind and other means, should there be different GE contamination tolerance percentages by crop?

The Intersection of Plant Breeding and Federal Policy

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With the Farm Bill debates heating up, this presentation works to help people in all parts of the movement better understand how their needs with regard to seeds are translated into policies at a federal level. This will be an informal discussion on what the National Sustainable Agriculture Coalition (NSAC), Rural Advancement Foundation International (RAFI) and other policy groups do to advocate for legislative change. This will be a safe space for participants to ask any questions that they have regarding the process. The intent of the presentation is to build a clear bridge between the needs of stakeholders and policy on Capitol Hill.

The 2018 Farm Bill must scale up investments in public seed breeding research and public cultivar development to enhance the resilience of our food system, widen farmer choice in crop varieties, expand opportunities for innovation and new markets, and bring diversity back to agricultural research and seed breeding. By investing in farmers' most foundational tool – the seed – we can help to ensure a sustainable and robust American food system for years to come.

The critical realm of classical plant breeding research for the development of locally adapted and publicly held cultivars has dwindled because of a shift in federal research funding toward more expensive genomics research, the widespread practice of private patents, and the subsequent private control of germplasm developed using public funds. In addition, funding and policy decisions by USDA and land grant institutions have put the entire profession of classical plant breeding in jeopardy. Plant breeding departments at universities are shrinking in both resources and capacity, and graduate students are left with few options to pursue a career in public sector breeding.

Overall, the pool of available germplasm is narrowing, with publicly developed seed varieties rapidly disappearing. Entire regions of the country lack adequate seed varieties that are adapted to their changing geographic and climatic needs, including the ability to resist or combat newly emerging pest and disease challenges. As a result, farmers no longer have a full spectrum of plant varieties available to meet the needs of both a changing climate and a competitive global agricultural economy, and consumers are denied foods that meet both their preferences and nutritional needs. There are several areas where the Farm Bill can strengthen research efforts:

1. Funding: Ensure that annual USDA extramural research funding supports public cultivar and breed development to ensure a viable "pipeline" of the next generation of plant and animal breeders

Since the passage of the Morrill Act and the establishment of the land grant university System in 1862, federal funding has been the lifeblood of public plant and animal breeding programs, which have driven the development of new and improved seed varieties and animal breeds. However, there has been a steady decline in our national investment in public sector breeding programs and over the past 20 years alone we have lost over a third of our country's public plant breeding programs. This slow atro-

phy of public funding to support improved plant varieties means that farmers have been left with fewer and fewer seed choices over the years and are ill-prepared to meet 21st century needs.

Without renewed funding for the development of publicly available plant varieties, American farmers will be at a competitive disadvantage and struggle to meet the future challenges related to climate change and food security, and less able to take advantage of economic opportunities within the value-added, artisanal, organic, and local and regional food markets.

Across the nation, once-strong public plant and animal breeding programs at our land grant universities have disappeared. Routinely, as public plant and animal breeders retire, their positions are not being refilled. New positions in the field are not being created, and graduate student interest is not being tapped sufficiently to replace existing breeders because of fewer faculty resources and fewer research opportunities due to the lack of ongoing, dedicated funds from the federal level. As the number of publicly funded plant breeders continues its decades long decline, it becomes increasingly urgent for Congress to support the next generation of public plant and animal breeders.

2. Coordination: Establish a Seeds and Breed Coordinator within USDA's Research, Education, and Extension (REE) Office

A number of USDA research programs currently support public plant and animal breeding research to varying extents, including the Agriculture and Food Research Initiative (AFRI), Specialty Crop Research Initiative (SCRI), formula (or capacity) funds, and longer term research trials conducted by the Agriculture Research Service (ARS). However, because there is no single USDA research program dedicated to public cultivar development, it is very difficult to assess total federal investments in public breeding research.

The next Farm Bill should therefore establish a coordinator position within the USDA's REE office who will be charged with harmonizing and tracking public plant and animal breeding research activities within and between REE agencies and in close coordination with the recently re-established National Genetic Resources Advisory Council (NGRAC). The coordinator shall work with designated personnel appointed by the Secretary to coordinate breeding efforts within the National Institute of Food and Agriculture (NIFA) and ARS.

A centralized coordinator will also help to track and identify the needs of the private sector, including farmers and consumers, as well as identify gaps in breeding research that are currently not being met by either the private or public sector. USDA has previously attempted to assess areas of underinvestment in plant breeding and this will be a core function of the coordinator to prioritize areas of the highest need for public breeding research. Additionally, the coordinator will ensure that taxpayer dollars are not funding duplicative research (either across USDA or within the private sector) and are only funding the highest priority and most relevant research that meets the specific needs of farmers in every agricultural region across the U.S. The coordinator would also be responsible for ensuring that the legislative funding mandate for public breeding is reached through the various programs.

3. Data Reporting and Metrics: Direct USDA to report to Congress on progress in meeting targets relative to a baseline, the number and types of cultivars developed through USDA-funded research, existing gaps in breeding, and any priorities established by USDA for future research investments.

In addition to establishing a baseline of competitive breeding research and ensuring coordination across agencies and the private sector, more accountability and transparency is needed to ensure that the private and public sector can monitor public investments in breeding research.

Due to a diffuse and often patchwork funding structure that supports most longterm breeding research, it is difficult to fully understand the return on investments in public sector breeding. Not only does this research happen across multiple programs, and multiple agencies, but often research results (i.e., new varieties developed and adapted by farmers) are not realized until years later.

The next Farm Bill must address the lack of data and accountability and require that the USDA monitor, track, evaluate, and ultimately report on the scope and depth of plant breeding investments to ensure that federal funding for public cultivar development research is both strategic and adequate.

In this era of budget-cutting, it is essential that Congress and taxpayers alike understand the return on any federal investments, including public plant and animal breeding research, to justify federal funding and help target areas of future investments.

This reporting and accountability requirement should be administered in a way that makes the data publicly available, user-friendly, interactive, and available to stakeholders from a wide range of disciplines to ensure that research gaps can be identified and areas of duplication can be minimized.

4. Stakeholder Input: Require the Secretary to convene regular stakeholder listening sessions to provide recommendations on national and regional priorities for public cultivar development and NIFA competitive grant programs

In order for USDA research investments to be responsive to current and emerging needs, the department must work closely with and facilitate dialogue between public- and private-sector plant and animal breeders, as well as farmers, to establish and modify public research priorities.

One mechanism to facilitate this public-private partnership is to solicit public input on research priorities by convening regular stakeholder listening sessions or other venues for providing formal input. It is through this public engagement that USDA will be able to most effectively identify high-priority areas to target federal research investments in public breeding. Farmers and ranchers have a unique understanding of the specific breeding traits required for their regions, as well as the market realities and environmental or production challenges. It is essential that these end users of publicly funded research help drive future research investments to ensure federal research is strategic, relevant, and keeps pace with the needs of current and future generations of farmers.

Ultimately, this structured and formal process for USDA to solicit and receive public stakeholder input on federal breeding research investments will improve the effectiveness of USDA programs by focusing federal program dollars on the most worthwhile investments, as determined by farmers, ranchers and researchers themselves.

5. Plant Variety Protections to Support Further Research Innovations: Affirm that farmers have the right to save and use seed and that breeders have the right to share and improve all cultivars and animal breeds developed with public funds

The growth of utility patents and restrictive licensing agreements by major seed companies, as well as university technology transfer offices, has greatly reduced the flow of scientific exchange and innovation and is a major contributor to the accelerated loss of farmer and breeder access to seeds. Utility patents are often used in combination with Plant Variety Protection (PVP) certificates, but PVP certificates alone with restrictive licensing agreements can also stifle innovation by preventing plant breeders from further improving, or in some cases even trialing, protected seeds for research purposes. Seed varieties developed with public resources must be held in the public domain, with no restrictions on research, use as parental breeding stock, or farm-saved seed.

While utility patents and PVP are defended as being necessary for innovation, their current use poses a major violation of the intent of both the utility patent system and the Plant Variety Protection Act by stifling innovation. In addition, farmers are increasingly seeking non-patented seeds because of the growing cost and increasingly restrictive uses of such seeds, as well as need for new options to cope with rapidly growing weed, pest resistance problems and increasingly disruptive weather patterns.

Public breeding programs within our nation's land grant universities should have every right to retain royalties for new varieties developed, and these royalties are in fact an important source of funding to maintain the future research investments of university plant breeding programs. However, unfortunately there is not broad agreement across the land grant communities on assuring that these potential revenues streams are shared fairly with the actual plant breeder programs. Legal protections (such as patents) that are placed on intellectual property that is developed in part or in whole with public funding should not restrict the further use or improvement of that germplasm. With the increasingly consolidated seed market, our nation is at risk of handing over a key public resource – our nation's entire agricultural genetic diversity (in the form of patented germplasm) – to private interests.

The next Farm Bill should take immediate steps to ensure that Plant Variety Protection (PVP) or plant patents shall serve as the only authorized forms of statutory plant varietal protection, if required. If licenses or Material Transfer Agreements (MTAs) are used to protect cultivars bred with public funds they shall ensure farmers' rights to save and use seed and breeders' rights to share and improve them.

The Community Seed Network: Meaningful Connection and Sustainable Support for the Community Seed Movement in the US and Canada

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For years, the energy around the community seed movement has been growing across the United States and Canada. There's an incredible diversity of community seed projects springing up, from seed libraries and community seed banks, to seed saving community gardens, and regional seed exchanges. They're happening in neighborhood recreation centers, public libraries, nonprofit offices, and schools. The evidence is mounting. People value seed sovereignty and want to share seeds of open-pollinated plants with their community.

The initiatives that form this new, diverse and growing movement are typically maintained by the passion and hard work of volunteers at the neighborhood or community level. They may not be connected beyond their immediate community, and they may not have recurring funding, land, or resources to sustain their efforts in the longterm, but they are determined to make a difference. According to a 2017 survey of 400 community seed initiatives in Canada and the United States, the common goals of these projects included "community building," "connecting people to resources and educational materials about seed," and "distributing free seed." 83% of respondents indicated their projects were started in the last five years, and nearly half reported that they lack adequate budgets to meet the growing demand for their services.

Despite their newness, and lack of resources, these initiatives play an integral role in the sustainability and expansion of the movement for organic seed. They educate citizens about the critical role seed plays in our lives and help make the vital connection between seeds and food. They conserve varieties and ecotypes, labor to protect regionally adapted seed, and work to secure the world's biodiversity. They keep seeds in the public domain by sourcing, swapping, and freely sharing seed. And they expand the audience of people who will go the extra mile to buy local, open source, regionally adapted, and heirloom varieties of seed. For many families, communities, allotment gardeners, market farmers, backyard and amateur horticulturists, and citizens, these projects are the gateway to the world of seed saving they never even knew existed. According to our survey, 200 projects in the United States and Canada distributed seed to over 200,000 people in 2016.

The Community Seed Network (CSN) believes that their work is critical to the future of the seed movement. As such it has developed with a mandate to support and better connect these initiatives by providing educational resources, organizational best practices, and opportunities for networking and information sharing, as well as access to a platform for sharing and exchanging seeds. Operating as an umbrella organization, the CSN hopes to foster the kinds of meaningful conversations and connections that make community seed leaders visible as trailblazers and movement builders.

The CSN is led at the national level by Seed Savers' Exchange (USA) and USC Canada (Canada).

Seed Savers Exchange, based in Decorah, Iowa, is a nationally focussed organization dedicated to the conservation and promotion of the culturally diverse but endangered food and garden crop heritage of the United States through the collecting, growing and sharing of heirloom plants and seeds. Seed Savers Exchange relies on a two-pronged method we call participatory preservation. Our seedbank is important, but it isn't enough without our member community. Gardeners grow out a variety and save its seeds, allowing the variety to adapt to the growing conditions of the area. Without individual gardeners, we miss our chance to help seeds adapt to changing conditions, leaving our seed bank as a sort of museum for varieties that haven't changed with their environment. As a part of this process, SSE sees the work of community seed movement as essential to longterm conservation.

USC Canada is a Canadian charitable organization with active programs in 12 countries globally, including Canada, where its field program is known as The Bauta Family Initiative on Canadian Seed Security. With a strong focus on sustaining and promoting agricultural biodiversity, USC Canada pairs the formal tools of scientists with the hard-earned wisdom of farmers. We work with partner organizations to advance seed and food sovereignty by investing in farmer training and exchanges; supporting farmers as they develop new varieties of crops that are adapted to current climate realities; and working across sectors to promote the benefits of ecological farming, seed saving, and to protect the rights of farmers to save their own seed. Participation in the Community Seed Network is a key way for USC Canada to support the grassroots seed movement, making that important work visible at the national and international scale.

Community Seed Systems: New Networks to Build Synergies Among Seed Stewards

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Abstract

A movement of Community Seed Banks (CSBs), seed networks, and seed exchanges is growing in response to restricted access to genetic resources and to the expansion of on-farm seed saving and participatory breeding. Most initiatives aim to address the loss of agricultural genetic diversity and to enhance access to seeds adapted to local conditions that the market does not provide for adequately. Leaders of two projects will share experiences assessing and establishing seed conservation and exchange programs — the European DIVERSIFOOD project and the Community Seed Network (CSN). Presenters will share visions for the future of seed exchanges along with results of a recent survey of European CSBs. Learn about a new, unique web platform designed by CSN to help make community seed work visible at an international scale. Presenters will engage in discussions about how vibrant models of community seed systems bolster seed security and enhance biodiversity globally.

Introduction

Seeds are a main source of all food and agricultural production. On-farm seed practices have been responsible for the management, conservation and renewal of genetic diversity in agriculture. Scientifically supported breeding started only in the 20th century. Today, the seed sector appears to be divided into two major systems: a formal seed system (FSS) and an informal one (ISS). The ISS has remained important in terms of numbers of people using and depending on it. However, the FSS, enforced by public and private law and corporate interests, is dominant and tends to marginalize and rule out the informal system. While creating microeconomic dependencies for farmers, the formal system is not able to create sufficient crop diversity and adapted varieties to answer all local demands of farmers and consumers. That is one reason for the foundation of Community Seed Banks (CSBs) as part of ISS.

Community Seed Banks

CSBs have been founded since the early 1980s in many parts of the world, with various forms and functions. Their main aims are to address the loss of agricultural diversity and to enhance access to seeds adapted to local conditions that the market does not provide for adequately, often based on a participatory approach of community crop management and improvement. In recent years, several case studies and analysis on CSBs worldwide have been published. Most of these studies focus on examples from developing countries, whilst very little has been published on experiences from developed countries. CSBs in Europe are based on seed savers′ and farmers′ networks. Their role may be less existential for the members of the respective community compared to CSBs in developing countries with a high degree of self-sufficiency. However, they play an important role in European societies with re-

gards to the conservation and sustainable use of plant genetic resources and in all the cases where easy access to public genebanks is not granted to farmers and gardeners.

Defining Community Seed Banks

CSBs arrange facilities for storing seeds and/or of areas for growing collections, aiming at the preservation of genetic and cultivar diversity of crops and at making those seeds available. These facilities can be centralized for some CSBs. Other CSBs have a decentralized approach where several persons within the CSBs store seeds and manage collections. CSBs are managed by communities. Communities may be informal networks or formalized legal entities (e.g., associations, cooperatives) consisting of more than one member. CSBs belong to the informal seed system. They may be part of the third (non-profit) sector – e.g., civil society organizations. However, they neither belong to the first (public) nor the second (private for profit enterprises/market) sector. The community manages the seed bank following certain common objectives based on shared values and collective rules, creating a specific culture and identity. These rules may regulate access to the seeds and information, but also the way the objectives evolve – or anything else important for the functioning of the community.

DIVERSIFOOD Project

The DIVERSIFOOD project is working on the understating of CSBs in Europe with also a comparative analysis of the situation outside Europe. In 2016-2017, DIVERSIFOOD partners completed a European survey to identify the actors or the experiences already ongoing and mapping them on the website: www.communityseedbanks.org. After the survey in September 2017, DIVERSIFOOD organized a two-day meeting in Rome with the support of Bioversity International and the International Treaty on Plant Genetic Resources for Food and Agriculture, inviting also experiences from Nepal, Mali, Canada, Bolivia, Ecuador, China, and Ethiopia. The aim was to present and analyze the results of the survey with the participants. The questions addressed during the workshop were:

- What approaches, components and modalities characterize CSB models in "the West" in comparison to "the South," and what can we learn from each other?
- What are the strengths and weaknesses, opportunities and threats of "Western" CSBs?
- What policies and practices are required to promote the role of CSBs in Europe as safeguards and promoters of agricultural diversity?
- What roles could CSBs play in the future of agriculture in Europe?

In October 2017 the follow-up of the workshop has been presented in a dedicated side event during the session of the Governing Body in Kigali.

Presenters will share with participants their experiences based on the DIVERSIFOOD project and Community Seed Network. The workshop will give the possibility to have a thorough exchange between American and European actors, aiming at better understanding each other and improving common activities and exchanges.

Building Robust Seed Systems Across Canada: A Model for Bolstering National Seed Security
The Bauta Family Initiative on Canadian Seed Security

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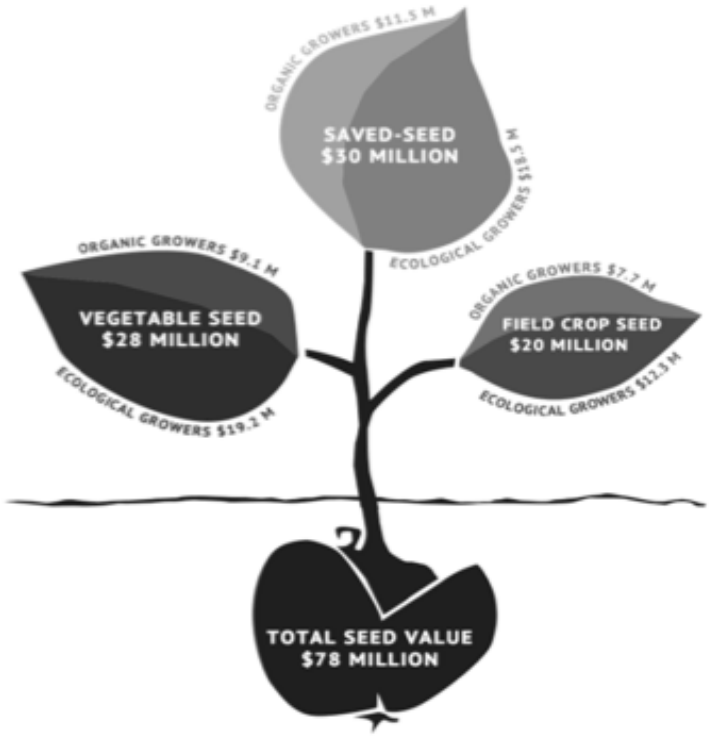
Context

The Bauta Family Initiative on Canadian Seed Security (BFICSS) has been supporting a national movement to build resilient seed systems in Canada since 2013. The BFICSS is delivered by USC Canada in partnership with national and regional food and farming partners across the country, with the support of The W. Garfield Weston Foundation. Through developing a series of regional, national, and international networks of farmers, seed producers, researchers, civil society, government, and the private sector, the BFICSS focuses on improving the quantity, quality, and diversity of ecologically-grown seed in Canada.

Inspired by USC Canada's agro-ecology and seed security programs across the world and the work of the Organic Seed Alliance, our work has been designed to preserve, improve, and create new seed diversity in Canada. Through taking a collaborative, farmer-led, systems-level approach that seeks to bridge sectors and geographies, our hope is to build a national seed system that is resilient to climate change and food security challenges in Canada.



State of Seed Diversity in Canada

The continued loss of agricultural seed diversity across the world is well-documented; in Canada, the situation is no different. Of the approximately 35,000 different seed varieties that have been used by Canadian farmers and gardeners during the past century, only about 25% of those varieties are preserved through Canadian seed banks. Of those remaining varieties, approximately only 10% are in circulation among Canadian growers, and the majority of those varieties are very vulnerable to market fluctuations and not being sustained in a stable way. Accordingly, there is a strong rationale to support a range of Canadian seed programs to ensure that seed diversity can both be maintained and improved in Canada.

Market for Organic and Ecological Seed in Canada

According to a 2014 study by the Canadian Organic Trade Association, Canadian organic/ecological seed purchases are valued at approximately $78 million annually ($28 million for vegetables and $50 million for field crops). Virtually all of the vegetable seed purchased in Canada for organic/ecological farming operations is imported, and approximately 30% of field crop seed used is not organically grown.

As such, there is a significant opportunity to increase the amount of domestically-produced organic/ecological seed in Canada to re-capture the market that is currently being serviced by international seed producers and/or conventional untreated seed producers.

On-Farm Participatory Research Programs

Goal: To support farmer-led improvement and farmer-led development of existing and new field crop and vegetable varieties adapted to organic/ecological farming conditions

National Participatory Plant Breeding Program
Farmer-Researchers: 78
Crops: Wheat, Oat, Potatoes
Partners: University of Manitoba, Agriculture and Agri-food Canada, Organic Federation of Canada

The flagship program of the BFICSS is a participatory plant breeding program for wheat, oats, and potatoes led by the University of Manitoba, public plant breeders at Agriculture and Agri-Food Canada (AAFC), independent plant breeders, and farmers across Canada with funding from Canada's Organic Science Cluster II. Funding from the BFICSS has enabled the work to expand the program from a handful of farmers in the prairies to 78 research sites across the country for all three crops in 2017. The project aims to accomplish the following goals:

- Develop commercially viable varieties of wheat, oat, and potatoes for organic and ecological farmers that contain the genetic variability needed for regional adaptation and climate resilience;
- Advance and promote breeding methods that integrate farmer selection into Canada's agricultural system and regulatory framework; and
- Advance knowledge on organic seed production, and improve the quality of ecologically grown seed in Canada, through effective farmer extension and support.

From the outset of the program, this project has attempted to apply a participatory plant breeding methodology across a wide geographic area. Farmers have been involved at all stages of development for the project, from designing breeding objectives, choosing parental lines, engaging in early generation selection, and in some cases, making the crosses themselves.

After three years of on-farm selection, early trials of farmer selected wheat populations have demonstrated that farmer-selected populations are better adapted to organic crop production environments than conventionally selected varieties.

In 2018, several of these populations may be ready to be evaluated for commercial release, and we are engaging in a process with growers to discuss how to commercialize these materials, while also ensuring that the material can remain in the public domain and be used for future public PPB projects. The progress of the PPB program has been incredibly encouraging so far and serves as a reaffirmation of the importance of PPB, and the benefits that can be generated when farmers are inclusively engaged as leaders and researchers in the process.

BC Seed Trials: Participatory Vegetable Variety Trials
Farmer-Researchers: 22
Crops: Golden Beets, Nantes Carrots, Leeks, Spinach, Kale
Partners: Farm Folk City Folk, University of British Columbia (UBC), University of Fraser Valley, BC Eco Seed Co-op

The BC Seed Trials project is collaboratively administered by Farm Folk City Folk and the Centre for Sustainable Food Systems at UBC Farm, with additional research support from the University of Fraser Valley. Primary project funding is provided by the BFICSS, UBC, the Investment Agriculture Foundation, and Whole Foods.

The BC Seed Trials aim to help farmers improve the availability of high-quality, well-adapted, regionally-produced vegetable seed for BC agriculture through the following research projects:

1) Quality testing of BC-grown seeds through lab evaluations and seed grow-outs at the UBC Farm research facility, and
2) Conducting "mother-baby" trials for 3-5 vegetable crops on a network of BC farms to evaluate BC-produced varieties with commercially imported varieties, testing for regional adaptation and seed crop potential.

In addition to generating a robust data set on how BC-grown varieties compare with commercially imported varieties, the project has served as an extremely important engagement tool with growers on regional seed production. With 22 farms participating in the project, and more slated to join in 2018, the program has been extremely successful in BC at engaging both farmers and seed growers about how to support and build the growth of regionally-adapted seed for organic conditions in BC.

<u>Capacity Building for Seed Producers</u>

Goal: To increase the capacity of the Canadian seed sector – seed growers, farmers, researchers, institutions, and the public – to support the improvement of Canadian seed quantity, quality, and diversity for ecological farming operations

Prairie Organic Grain Initiative
Crops: Cereals, Pulses, and Oilseeds
Partners: Manitoba Organic Alliance, SaskOrganics, Organic Alberta, the organic grain industry, Federal and Provincial governments

The Prairie Organic Grain Initiative is a four-year, $2.2 million tri-provincial project dedicated to achieving resilience and stability in the prairie organic sector by focusing on increasing the quantity and quality of organic grains, and developing relationships across the organic market value chains. It is

a partnership of the three provincial organic associations and the BFICSS with funding from the industry-supported Prairie Organic Development Fund, matched federal funding, and partnerships with several industry stakeholders.

The Prairie Organic Grain Initiative is focusing on improving the quality and quantity of organic grains through the development and distribution of educational research, mobilizing knowledge transfer from the latest organic agriculture research, and working with the organic value-chain to build organic grain infrastructure. The Initiative also seeks to support transitioning and new organic farmers by providing an integrated suite of educational and on-farm resources. Lastly, the project works to increase international and domestic markets for Canadian organic grains by working with the organic stakeholders to facilitate sales, address issues related to grain quality and infrastructure, and increase longterm demand for Prairie-branded organic grains.

By focusing on improving the quality of organic grains, the Initiative is supporting farmers to grow high-quality organic seed. Currently, organic growers have the following options to procure field crop seed for their operation: purchase double certified organic seed, purchase conventional untreated certified seed, purchase common organic seed, or save their own seed. The Initiative is seeking to educate growers on these options and how to do it well. Additionally, in working toward building a seed system that is resilient, the Initiative is working with growers to increase the diversity of field crops that are being grown through intercropping, as well as diversifying rotations, providing the agronomic and market support required.

Comprehensive Seed Education Programs
Crops: Vegetables and Field Crops
Partners: Seeds of Diversity Canada, Farm Folk City Folk, Organic Alberta, Atlantic Canadian Organic Regional Network (ACORN), Ecological Farmers of Ontario, Canadian Organic Growers

In Canada, there are no institutional training programs and very few informal training services on organic/ecological seed production. Since 2013, we have aimed to offer multiple, regionally-based educational forums where a wide diversity of audiences with varying levels of expertise can learn the full spectrum of seed production skills both on-farm and off-farm.

Through on-farm field days, conference seminars, seed mentorships, and online courses across the country, tailored to each region, we have offered over 150 different on-farm and off-farm training events reaching over 6000 participants in Canada. These programs have been organized to be responsive to the needs of farmers and seed producers, to increase technical skills on seed production, and create as many opportunities as possible for peer-to-peer knowledge sharing.

In April 2017, we partnered with Canadian Organic Growers to launch Canada's first online certificate program on Organic Vegetable Seed Production. This five-course, 22-week online certificate program offers a comprehensive intermediate curriculum covering the basics of organic seed production, seed economics, seed quality assurance, and on-farm plant breeding. The certificate is delivered in an online, blended-learning format that includes live, online instruction with teachers and guest experts.

Our hope is that through providing a combination of on-farm and off-farm training opportunities we continue to build the existing capacity of Canadian farmers and seed growers, while also training the next generation of seed growers in Canada.

Seed Diversity Conservation Programs

Goal: To support on-farm (in situ) seed conservation of Canadian field crop and vegetable seed in ecological farming conditions and conserve those varieties in ex-situ public seed collections

Vegetable Seed Grow-outs
Farmer-Researchers: 106
Crops: Vegetables
Partners: Seeds of Diversity Canada

Since 2013, in collaboration with Seeds of Diversity Canada, the BFICSS has been supporting an on-farm seed conservation and improvement program with vegetable farmers and seed producers across the country. The goals of the program have been to 1) support farmers in scaling up open-pollinated varieties of vegetables to farm-scale quantities that are suitable for ecological market garden production, and 2) increase the knowledge and skills of Canadian seed producers and farmers to produce high- quality vegetable seed.

For this project, we generate an annual list of open-pollinated varieties that are unavailable in bulk quantities from either local or international suppliers, but are in demand from ecological market gardeners. Canadian growers select varieties from that list to grow out for seed as well as a market garden crop. Participating growers then collect and submit data on their chosen varieties, and send bulk samples of seed to Seeds of Diversity's Seed Library, and keep bulk quantities of those seeds to re-plant and/or redistribute for next year.

The project grew from seven growers conducting trials on 20 varieties in 2013 to 106 growers conducting trials for 274 varieties in 2017. The project has served as an effective way to not only increase the amount of on-farm vegetable seed production in Canada, but to also build the capacity of ecological growers to improve commercial seed production skills.

Building Relationships from Seed to Fork

Ken Greene, SeedShed (Kitchen Cultivars); Julie Dawson, University of Wisconsin-Madison (Seed to Kitchen); Lindsay Wyatt, Johnny's Selected Seeds (Northeast Seed-to-Table Initiative); Brigid Meints, Oregon State University (The Barley Project); Lane Selman, Oregon State University (Culinary Breeding Network)

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Kitchen Cultivars

Kitchen Cultivars developed out of a desire to create market channels that would support the continued production of lesser known, but regionally significant, varieties for the longterm. We defined "regionally significant" in broad terms that encompass the many cultural, agricultural, and culinary aspects that can be associated with different varieties.

Seedshed's primary partnership for this program is Glynwood, a non-profit focused on farming issues in the Hudson Valley. We collaborated by splitting up our responsibilities. Seedshed took on the trials, grow-outs, and farmer partner coordination, while Glynwood was responsible for buy-in and participation of culinary professionals.

Farming partners included CSAs, market growers, wholesale growers, restaurant growers, seed companies, and educational farms. Culinary partners included Culinary Institute of America, restaurants, regional restaurant chains, and value-added producers.

Now in its third year, Kitchen Cultivars once again coordinated a region-wide grow-out of one variety to feature in restaurants, markets, and home kitchen distribution outlets. The program also expanded to include a mother-daughter trials component to help identify new varieties and collect relevant data on them. Other activities included taste tests from the trials, storage tests of winter varieties, dry bean threshing and winnowing education, and seed literacy education for farmers and chefs.

The single variety grow-out portion of the program faced climatic, training, budget, and oversight challenges this year. The most successful part was involving more participants in the trials, getting a diversity of agricultural and culinary feedback from everyone involved, and sharing the data in meaningful ways for each distinct demographic. Farmers learned how to incorporate trials of new varieties into their farm plans and were exposed to multiple new varieties that could fill gaps in local markets. Chefs experienced more food diversity than usual and developed relationships with more farms.

Our hope is to retool the single variety grow-out element of the program and expand the very successful trials component. While we will continue to strengthen these budding relationships, we hope to to find ways to include home cooks and larger farms in the program. The other pieces that we continue to work on are how we identify new varieties for the program, how we communicate about the program to a wider audience, and ways of securing reliable funding.

Finally, we also consider the seeds themselves to be partners in this program. We want to create a healthy regional seedshed. At the same time that we're supporting the farmers and chefs, we also strive for the seeds themselves to benefit by forging relationships with caring and knowledgeable market makers. By considering seeds, seed growers, chefs, food farmers as equal partners, we hope Kitchen Cultivars will deepen our region's relationship with regionally adapted, delicious, and culturally diverse local foods.

Seed to Kitchen

Organic farmers need high-quality produce to be successful, and varieties with improved disease resistance and agronomic traits need to have the high quality expected by consumers. While many breeders taste everything they select, it is not easy to evaluate flavor as part of a breeding program. The goal of the Seed to Kitchen project is to bring breeders, farmers and chefs together for more informal conversation about desirable variety characteristics, and to develop better methods of evaluating flavor systematically in breeding and variety trial programs.

The chefs we are working with are very committed to supporting local organic farms and have advanced the local and organic food movement through promoting farm to table. Chefs provide information to breeders and to farmers on their preferences, desired characteristics, and needed improvements. Chefs are often able to articulate flavor preferences more precisely than general consumers and can provide breeders with feedback on particular aspects of varieties that need improvement, without needing to taste all breeding lines or varieties in a program. We use a two-step strategy with the flavor evaluations: first, tasting all varieties in a trial with our field-crew, after a small amount of training, then using the data from these evaluations to select a more limited number of varieties for the chefs to evaluate.

Chefs involved in the Seed to Kitchen Collaborative have been recruited primarily through word of mouth, with farmers recommending chefs that they work with, and chefs inviting other chefs that they think would be interested in the project. We evaluate a different crop each month and typically have about six chefs participating in the evaluation. The relationships we have with the group of participating chefs have been developed over the past four years, and we have sought to understand what formats of evaluation work best for the chefs involved and provide useful information to breeders. We have moved from more quantitative to more qualitative evaluations of each variety and make use of rapid sensory evaluation methods, such as projective mapping (a similarity based evaluation method) to both reduce the time needed and to improve the utility of the information we get. The chefs state that they enjoy the evaluations because they get exposure to interesting varieties that are not yet on the market, because they value working with UW-Madison on a project directly relevant to local needs and because they would like to have an influence on the varieties that will be available in the future.

Moving forward, the chefs have requested more time for discussion with the breeders, including information on the basic components of flavor for particular vegetable crops, and more information about the breeding goals beyond flavor. It can be challenging to fit both evaluations and significant discussion into the time that chefs have available in their busy schedules, but we are working on strategies to streamline tastings and provide more information immediately after the evaluations to the chefs. There is also interest in developing lexicons for each vegetable

based on previous evaluations to make it easier for chefs to quickly describe different varieties. Finally we would like to continue to expand the group of chefs to include many different types of cuisine.

Northeast Seed-to-Table Initiative

Inspired by the work of Lane Selman and the Culinary Breeding Network, the Northeast Seed-to-Table Initiative (NESTI) began in June 2016, when a group of Johnny's Selected Seeds employees passionate about culinary breeding formed a partnership with Colleen Hanlon-Smith and the Unity Food Hub. NESTI is a network of farmers, chefs, breeders, food distributors, and food enthusiasts working to strengthen the local Maine food system by sharing expertise with one another through tasting events and dialogue. Our mission is to align breeding goals, grower needs, and market demand for unique, flavorful, high-performing varieties by involving all the interested parties in an open, creative, and constructive forum.

In its first year, NESTI held its first Seed-to-Table Variety Tasting Event, hosted guest speaker Lane Selman for a day-long culinary breeding workshop, and conducted a culinary breeding focus group with local grower and chef partners. The event allowed us to forge relationships with growers and chefs by recruiting them to participate in this public-facing event, starting with people who had existing relationships with Colleen Hanlon-Smith and the Unity Food Hub. The event showcased the goals and potential of culinary breeding to both the chef and grower participants and other attendees.

In its second year, NESTI coordinated partnerships between growers, Johnny's plant breeders, and chefs to trial and evaluate new Johnny's breeding material and present it to the public at the second annual Seed-to-Table Variety Tasting Event. These partnerships provided valuable feedback to Johnny's plant breeders on new and experimental varieties. One particularly successful aspect was the increased emphasis on value-added producers as chef partners, which extended the seasonal reach of our events and even allowed a coast-to-coast chef partnership in which preserved products were sent to Oregon and prepared by Oregon chefs as the basis for dishes for the 2017 Culinary Breeding Network's Variety Showcase.

Participation in culinary breeding trials and events can help our local growers in diverse ways. NESTI has acted in a networking capacity by connecting interested growers to Johnny's plant breeders, allowing them to evaluate pre-commercial varieties, give feedback that shapes which products are released, and get a preview of upcoming releases. NESTI also acts as a forum in which growers can make their needs known to plant breeders, resulting longterm in new varieties that better reflect local and regional grower needs. In addition to meeting grower needs, varieties developed with culinary breeding feedback are also better tailored to consumer preferences, with the goal of increasing both direct-market and wholesale sales to restaurants and other local businesses. Culinary breeding events can also create more immediate consumer demand for new and existing varieties and act as a networking opportunity between growers and local restaurants. Finally, the public education aspect of culinary breeding events helps to increase overall understanding of the food supply chain and drive demand for locally-grown, high-quality vegetables, fruits, and grains.

Moving forward, NESTI goals include holding additional public-facing educational events as well as small grower-chef-breeder tasting events and focus groups to gather feedback on potential new vegetable varieties that Johnny's breeders can use to develop and release varieties that better meet grower and consumer needs.

Barley Breeding for Culinary Uses

The Barley Project at Oregon State University (OSU) began breeding barley for food end-uses in the mid-2000s in response to an increased interest in barley for human consumption as new studies were published demonstrating the positive health benefits of barley. In order to successfully breed culinary barley, the barley breeding project teamed up with Andrew Ross, a cereal chemist at OSU, to conduct test bakes and functionality analysis with new varieties and breeding lines. In 2016, the barley project first participated in the Culinary Breeding Network Variety Showcase and partnered with Lane Selman. Additionally, partnerships were formed with regional farmers, bakers, chefs, pasta-makers, and maltsters to produce, experiment with, and promote new varieties of barley for culinary purposes.

Because the majority of past barley breeding work in the U.S. has focused on malt and feed barley, quality parameters and market classes have not been established for food barley. Several traits, including hull retention, kernel hardness, beta-glucan content, starch type, water absorption capacity, seed coat color, and several dough properties were identified as useful traits to measure for food quality. Flavor and texture were also identified as important traits to measure.

Starting in 2013 at the annual barley field day, several varieties of barley were steamed in rice cookers and participants were asked to taste and record their opinions on flavor, texture, and appearance. Since then, steamed barley varieties and breeding lines have been prepared for tastings at field days, the Grain Gathering conference, the Organic Seed Growers Conference, Organicology, and the Good Grains Event. These tastings are useful for both researchers and participants. They serve as a platform to educate participants on the potential culinary uses for barley and where to source grain. Researchers gain insight on preferences that can assist in future breeding work.

At the 2017 Grain Gathering, Andrew Ross, Lane Selman, and Brigid Meints presented a workshop on culinary barley. Four varieties and breeding lines were prepared four ways: barley bread, steamed grain, barley biscuit, and roasted barley tea. Participants rated the steamed grain, biscuit, and tea using a nine-point hedonic scale. The bread was tasted using a descriptive analysis. Participants put a great deal of thought into their sensory analysis and the workshop was very productive and served as a model for future tastings events.

The OSU barley project was recently awarded a USDA Organic Research and Extension Initiative (OREI) grant to breed multi-use naked barley for organic systems. Four other universities in the Pacific Northwest, Midwest, and Northeast are also involved in this project. This project includes a large outreach component including tastings and workshops around the country that will provide a broad range of information on barley lines that can help inform the breeders on breeding strategies for culinary barley.

Culinary Breeding Network

In 2012, the Culinary Breeding Network (CBN) was created with a goal to increase communication and create collaboration between plant breeders and stakeholders to develop more relevant and desirable cultivars for all parties. Stakeholders include farmers, chefs, processors, wholesale and retail buyers, culinary educators, home cooks, nutritionists, and eaters in general. Incorporating these stakeholders into the plant breeding process gives breeders deeper insight into preferred traits while increasing awareness and understanding of organic plant breeding among a broader audience.

CBN frequently functions as the communication and outreach platform for various university research projects involving organic farmers. CBN identifies and creates relationships with potential project stakeholders, builds community within research projects, and creates engagement through interactive events and activities to communicate project goals and findings.

The trademark event of the CBN is an annual Variety Showcase, where attendees have the opportunity to taste commercially available cultivars, provide feedback on breeding populations, and exchange ideas and perspectives directly with breeders. Event attendance has increased more than five-fold in the four years it has been held to 540 attendees at the 2017 Variety Showcase. Attendees have been exposed to over 200 commercial cultivars and 170 breeding lines of vegetables and grains.

Seed companies report significant sales increases as a result of the events. Farmers report that new knowledge and experience gained at this event impact their work by expanding networks, changing their buying practices, and better informing their decisions. Creating a venue for interactive exchange of specific needs has resulted in a greater understanding for breeders of what consumers want and, for all other participants, a greater understanding of the important role breeders play in the food we eat.

Moving forward, CBN hopes to collaborate with other breeder, farmer, and chef alliances; host events in other parts of the country; and spread its mission to broader audiences beyond the food and agricultural community.

The Power of Seed Hubs in California

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California has the largest organic specialty crop industry in the U.S., representing more than 60% of the national acreage. There is a large unmet demand from California's organic specialty crop industry for seed produced in and for organic farms and adapted to their climates.

OSA has been actively working in California to develop regional seed systems. Our approach to strengthening regional seed systems in California has been hub-based. Each of California's agricultural regions has its own climate, production practices, markets, demographics, and culture. Each of these regions requires a tailored approach.

OSA has initially focused on five geographically based hubs in California: the North Coast, the Northeast, the Sierras, the Bay Area/Central Coast, and the South Coast. Each of these five seed hubs are overseen by a hub leader who is deeply involved with the local seed movement in the area. Thanks to support from the USDA Specialty Crop Block Grant program, each of the hubs has a budget to collectively purchase seed cleaning equipment. A wide range of equipment has been acquired and has helped many seed producers expand.

There is also an education program that involves seed production workshops and field days at farms in each region. The workshops are tailored to the audience in attendance and focus on either introductory seed production basics or on-farm variety trials and breeding. These workshops and field days are held roughly once a year in each region. Through a collaboration with the UC Davis Seed Biotechnology Center, we have also sent several students to their one week Seed Business 101 intensive both in 2016 and 2017. The graduates then took what they learned back to their communities and shared the information through seed business workshops.

These regional hubs are linked to the larger California network by several events and initiatives. One of the key events has been the annual California Seed Summit. This year we are celebrating the 4th summit which will take place in Petaluma, just two weeks after the conclusion of the Organic Seed Growers Conference. This gathering of California seed professionals, academics, and stakeholders has evolved over the four years and is a springboard for regional development for the following year. It has been a chance for growers to network with each other, connect with distributors, share information and strategies, and brainstorm to develop larger projects.

The Seed Grower Directory is a concept that came out of a marketing need identified in one of the first summits. The directory aims to highlight California organic seed producers, the crops they grow, and an overview of their operations in a sleek and organized catalog that can be circulated among larger distributors or people looking for regional seed. The print version will feature only California in 2018; however, this is a jumping off point for an online platform that will serve the same purpose nationwide.

Finally, a new CA Organic Trial Network initiative will support on-farm organic variety trials throughout California. This project provides mini-grants to farmers to conduct trials, support in designing and analyzing the trials, and a platform for farmers to share their results and learn from one another. This is one of California's newer projects and has potential to yield great things!

Regional Seed: Success Stories

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Introduction

Historically speaking, seeds and seed sharing were predominantly regional. But seeds quickly became global in nature. At first this globalization was through hand to hand seed sharing and the slow migrations of people. Today it's a globalization on a different scale. Continued consolidation of seed resources by fewer and fewer large corporations has led to a massive erosion of regional seed varieties as well as the disappearance of regional seed systems.

Recently there's been renewed interest, urgency, and creativity around restoring and reinventing regional seed. This has taken many forms, including seed libraries, community seed banks, individual seed collections, cultural seed stewardship and regionally focused seed companies.

Defining Regional Seed

This slow-to-start but now enthusiastically embraced return to the concept of regional seed means the idea has not yet caught up to reality. Calling germplasm "regional" can mean different things to different people. We can talk about the geography of regional seed in terms of where seeds come from, the agricultural performance of seeds in terms of how adapted they are to a specific bioregion's climate, as well as human elements such as their significance to a particular cultural group.

Is a "regional heirloom" local just because the description names its most recent place of origin? Is a "regional seed system" regional just because a seed company's headquarters is in a specific state? Is a seed "regionally adapted" just because it's being produced in certain social/politically defined boundaries?

Through exploring a diversity of regional seed success stories from some of the leaders in the regional seed movement, we hope to start to understand the term "regional seed" and foster a larger conversation about the value of regional seeds on a national level.

Don Tipping: Regional Seed Success Story for Siskiyou Seeds

Back in the winter of 1996 the idea of Seven Seeds Farm was birthed on the north slope of Sugarloaf Mountain — a wild northern spur of the rugged Siskiyou Crest that straddles the Oregon/California border. The dream was to inspire others to honor water, soil, food, animals, nature and each other by doing just that. Since then we've always been rooted deeply in the fertile soil of a "show me, don't tell me" ethos. Farming as a means to the ends of living simply on the land, grateful for being connected to the sources of sustenance, surplus as an outgrowth of tend-

ing the land and a farm business as a vehicle to sharing it. Twenty-one years later, we are still at it on the same mountainside, alongside the same delicious spring-fed creek, still saving seeds and marveling at nature's compelling beauty.

For many years we produced large quantities of 40+ organic vegetable and flower seed varieties per year for many different national-scale seed companies. Then in 2009, after a number of years of beginning to dabble in plant breeding and varietal improvement work, we were ready to hang our own shingle and thus Siskiyou Seeds was born. Since then we have gone from growing all of the seed ourselves on 3-4 different fields scattered around our valley to producing about 60% of the seed ourselves and working with other skillful organic seed growers throughout the Cascadia bioregion to create a diverse offering. We are located at 2,000' elevation, 42.5° North Latitude. Our average frost-free season is from June 1st until October 15th. We are a USDA Zone 7 site. We have learned through the school of hard knocks that we are not in a favorable climate to grow crops such as cauliflower, cabbage, broccoli, peas and spinach seed. Fortunately we can grow pretty much everything else here in the "banana belt" of southern Oregon. So we have evolved to a model in which we grow about 100-150 varieties at our home farm and at one leased field two miles downstream. The remainder we buy from other artisanal organic farmers whom we list in our catalog and website, including their website in case they offer direct sales of their seeds.

Many of the varieties that we steward have been grown in this valley for over 40 years, so we have gotten the unique opportunity to compare and trial well adapted varieties with those from other regions. Our farm model strives to coax the potential of the genetics of a variety from it, rather than relying upon external crop supports such as row covers, plastic mulch, bio-control sprays and such. We are excited for the tremendous potential of genetic adaptation to become the new norm of regenerative agriculture, wherein we help plants thrive "from the inside out," rather than the traditional industrial agriculture approach of "outside in" with chemical sprays and fertilizers. Those of us at the vanguard of regenerative agriculture as seeds-people have the unique challenge of stewarding a large collection of botanical diversity that may be unprecedented. We can't simply move material from one part of the Earth to another and expect them all to thrive. Many crops are malleable like that, but others are not. The industrial seed model grew important seed crops in the regions where they do best, so we have a unique challenge of adapting the whole cannon to grow in our bioregion. This may or may not be possible. We won't know unless we try!

We here at Siskiyou Seeds see ourselves as more of a service entity than a pure producer. Insofar as we help to facilitate gardening in our region. While others from around the country (and the world) may obtain seeds from us, we cannot guarantee that they will thrive in areas outside of our wheelhouse of the Pacific Northwest or as I am fond of viewing it, "Cascadia." What we can do is continue to trial, select and refine the repertoire of varieties that demonstrate reliable traits of vigor, flavor, adaptation to pests and disease, beauty and charm. Onward and upward!

Bill McDorman: The Story of Candy Mountain Corn

While attending the University of Montana in 1976, I purchased a little old house on the old north side of Missoula. In the backyard was a long abandoned garden. Only later, I found out it

was Mrs. Sorge's famous tomato garden. On what turned out to be a long adventure to find the best seeds for me to plant in this garden, I discovered Fisher's Garden Seeds in Belgrade, Montana. Ken Fisher and his wife and a neighbor friend had run a small packet seed company since just after the Second World War. Ken grew much of the seed on his own five-acre lot. He and his wife and neighbor cleaned it and packaged it in color seed packets printed on his own desktop, offset press. He also printed a small mail-order seed catalog that he mailed himself. Each spring he would drive around Montana and deliver 40 seed racks filled with the packaged seeds for such favorites as Montana Marvel peas, Mountaineer squash, Northern Lights tomato, Montana Green beans, Fisher's Earliest Corn and what became my personal favorite, Candy Mountain Super-sweet corn.

Ken had produced all these regional treasures by selecting survivors in his harsh climate over decades. Mountaineer was a 68-day blue hubbard squash and Fisher's Earliest a 60-day Bantam corn. Fisher's Earliest once survived nine frosts and two hailstorms one summer and still produced corn for me at 5,300 ft. elevation in Hailey, Idaho. My favorite of all was Candy Mountain corn, 70 days to maturity. I get a kick out of recent claims by breeders who have produced the world's first open-pollinated, super-sweet corn. Ken Fisher produced Candy Mountain by stablizing a line of Kandy Corn, one of the very first super-sweets. He began working on this project in the late 1960s.

Ken gave me seeds for Candy Mountain in 1979. With his permission, I grew and sold seed for Candy Mountain through my mail-order seed company, High Altitude Gardens, for 28 years. We always claimed it to be the world's first open-pollinated, super-sweet corn. To this day, I believe each region still holds many, largely-undiscovered treasures like Candy Mountain that deserve our attention.

Ken Greene: Hudson Valley Seed Company and Seedshed

In 2004 I started the first seed library in a public library in the country. I didn't have a good grasp of seed systems, I didn't know much about seed saving, and I didn't know what would happen. What I did know is that seeds — especially local varieties with local stories — were fascinating and I hoped that maybe, by using the power of community, we could make sure they didn't disappear.

This year we're celebrating our 10-year anniversary of the Hudson Valley Seed Company and going into the second year of Seedshed, our new non-profit. My work developing a regional seed company and my work growing community through the power of seeds go hand in hand. I have found that the true regional seed success stories for us involve many people — not just the release of a new variety through our catalog. And these successes aren't about just one facet of regional seed but contain elements of agronomic adaption, regional economics, and cultural significance.

<u>Hank's X-Tra Special Baking Bean</u>

This humble white bean was the first seed donated when I started the original seed library. A local variety from the library director's father, I kept it alive by growing a little bit of it out every

year for eleven years. But just keeping it alive didn't feel like success. It felt like museum preservation. I wanted Hank's to have a life of its own, in many hands. I wanted the story to continue.

Hank's Bean was the first variety we featured in Seedshed's Kitchen Cultivars program. The idea was to engage farmers and chefs with local varieties to create a market that could independently sustain endangered (or just unsung) regional varieties. Twelve farms, ten chefs, and the Hudson Valley Seed Company collaborated with local non-profit Glynwood to see if by growing community we could save a local seed. Because we organized a guaranteed market for the bean, farmers were willing to try growing them. Because the dinners at the restaurants featured a named variety with a local (and touching) story, food consumers wanted to try the bean.

Thanks to this community effort, there is now more Hank's Bean being grown and consumed in the Hudson Valley every year than there ever was in Hank's backyard in Ghent, New York. Hank's X-Tra Special Baking Bean even got its 15 minutes of fame by being written up in *The New Yorker*.

Some of our other success stories involve very different scenarios:

- Bridge to Paris Pepper, a dehybridized sweet pepper, collaboratively transformed into an OP that outperformed hybrids in its class in trials conducted by the Northern Organic Vegetable Improvement Collaborative (NOVIC).
- Haudenosaunee varieties from Rowen White cooperatively grown out on their native soils to be rematriated to the Iroquois/Mohawk community in Akwesasne.
- Cornell-bred varieties returning to their roots.
- Varieties arriving with immigrants just at the beginning of their journey in a new home.

These are all regional seed stories because they focus on seeds, not as commodities, but as living organisms, ever evolving, that need a home with a community that cares about them. As Seedshed continues to develop, we hope to find ways to map regional seedsheds identify dams preventing the flow of seeds through communities, and follow the strong currents of regional seed success stories all over the country.

How to Succeed with Regional Seed

Jay Bost and Daniela Dutra-Elliot, Hawaii Seed Growers Network

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Hawai'i has strong dependence on imports with approximately 85% of its food being brought in from out-of-state. At the same time, it has the distinction of being the most isolated populated landmass in the world, and thus is highly vulnerable to disruptions in import supplies. In the past several decades, Hawaii's agriculture has been transitioning from large-scale, corporate, export-oriented production to small, entrepreneurial agricultural entities that produce primarily for the local market. This major agricultural transition and the growing public demand for local products have provided new opportunities in diversified agriculture.

There are many barriers for local food production, including sourcing of seeds that are adapted to local conditions. Farmers and gardeners are purchasing seeds that are adapted to temperate conditions. Others utilize varieties bred decades ago by University of Hawaii (UH) breeders. Pest and disease pressure in the islands can be high due to the lack of winter in most low elevation sites, in addition to the constant introduction of new pests and diseases through trade. While most of the growers in the U.S. can rely on seeds from several reliable commercial sources, Hawaii growers have to look widely and experiment to locate appropriate seeds. Often the specific needs of Hawaii's growers are not important to large seed companies or even small, regional mainland companies. Meanwhile, the breeding program at UH has continued to shrink due to lack of funding and a nationwide move from the field to the lab.

The Hawaii Seed Growers Network (HSGN), a statewide group of seed producers, has worked for more than five years to grow, develop and provide high-quality local seeds to Hawaii's gardeners and market farmers. It grew out of the Hawaii Public Seed Initiative (http://kohalacenter.org/hpsi), started by UH faculty and concerned farmers and gardeners, with input from Organic Seed Alliance and others. Establishing local seed sources for Hawaii is a slow process with a steep learning curve since resources are scarce. The main foundation of the work is through selecting seed sources from GRIN, retired or retiring UH breeders, or from other tropical areas and trialing those cultivars to select for those that show promise to be pest and disease resistant while being culturally desirable for the local market. Another issue for local seed growers is the identification of cultivars that will produce seed without vernalization and can deal with often high humidity during seed maturity.

The growers in HSGN have selected several cultivars that show promise and are offering them at an online store, with this initial work having been funded by a Specialty Crops Block Grant and also generously funded by the Ceres Trust. This is just the beginning of a long process to have in the future more locally adapted varieties that can be produced and offered locally. HSGN collaborates with a farmer training program and an agricultural program at a community college, integrating cultivar selection into their programs. By integrating these activities into curriculum, students are exposed to variety trials and seed production and in some cases take the information and experience in deeply and become part of the seed community themselves, aiding its expansion.

This March we are happy to be hosting a Northern Organic Vegetable Improvement Collaborative (NOVIC) Fundamentals of On-Farm Breeding for Organic Systems workshop, which will further build capacity locally. We hope that the Hawaii Seed Growers Network becomes a viable way for new and experienced seed growers and amateur breeders to market seeds and a go-to seed source for growers looking for seeds adapted to Hawaii's wonderful and sometimes challenging growing conditions.

Cultivating Diversity in the Seed Movement: Resilient Seeds and Diverse Communities

Rowen White, Indigenous Seed Keepers Network; Kristyn Leach, Namu Farm/Second Generation Seeds; Owen Taylor, Truelove Seeds; and Ken Greene, Seedshed

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Overview

During this session, we will look at diversity of the seed movement not just in relationship to plant biodiversity, but to the communities of stewardship as well. The three panelists and moderator all work with culturally diverse communities in revitalizing culturally relevant seed systems. Rowen White will share her work with the Indigenous Seed Keepers Network; Kristyn Leach will share her work in the Bay Area of California about the Second Generation Seeds project, working with Asian-American farmers; Owen Taylor will share his work with Truelove Seeds, a collaboration with urban and rural farmers committed to community food sovereignty, sustainable agriculture, and preserving ancestral foodways through seed keeping; and Ken Greene will offer insight on his work with Seedshed and the Hudson Valley Seed Company as moderator of the panel.

Each of the presenters will offer their perspective on the following questions:

- Can we envision the Seed Commons and coordinate collaborative efforts to care and protect for our seeds that is in right relationship with a diverse array of voices from unique cultural communities?

- How does the food justice movement fit within the organic seed movement?

- How can this seed work help us embark upon regenerative forms of economic development and production techniques that align with the cultural values of the communities we are working with?

Rowen White, Indigenous Seed Keepers Network

The diversity of seed crops from Native North America is remarkable; the numerous colors, textures and flavors of indigenous resilience held in purple corns, zebra striped beans, bright orange squash, and a plethora of other traditional landrace varieties. Yet the diversity that has been cultivated over millennia in the hands of Native American farmers has been disrupted and displaced over the last century, as tribal communities have witnessed extensive economic, political, ecological and cultural realms. The end result of a large number of intercultural and governmental policy-generated disincentives has been the demise of a large percentage of traditional farming of native crops in tribal communities. In response to this, we have been working to establish the restoration of regional seed systems and indigenous trade routes as a part of the Indigenous Seedkeepers Network. As a collective of Native Americans, coming from cultures where agriculture is at the very heart of our cosmologies and lifeways, we understand that seeds are our precious collective inheritance and it is our responsibility to care for the seeds as part of our responsibility to feed and nourish ourselves and future generations.

What is the importance of cultural memory, tradition and community in the restoration of regional seed systems that steward agro-biodiversity? How can we leverage culture and community as a mechanism to restore healthy seeds and seed systems? Conversely, how can we strengthen native seeds and traditional agriculture as a mechanism to maintain cultural traditions? How can we work cross-culturally to ensure we have access to our seed resources, but assist other small farming communities in the deep reconciliation work of sharing seeds with integrity and respect to communities of origin. In this panel, we will be sharing our story of the dynamic interface between cultural identity and genetic diversity of seeds. Can we envision the Seed Commons and coordinate collaborative efforts to care and protect for our seeds that is in right relationship to our indigenous cosmologies? How do we recreate regenerative seed and food economies that doesn't treat seeds as objects or commodities but as living breathing relatives? These are the questions we are looking to answer in our quest to build resilient indigenous seed networks and cooperatives.

The mission of the Indigenous Seed Keepers Network (ISKN) is to nourish and assist the growing Seed Sovereignty Movement across Turtle Island (North America) within tribal communities. As a national network, we leverage resources and cultivate solidarity and communication within the matrix of regional grassroots tribal seed sovereignty projects who are working to not only restore, conserve and selectively breed culturally appropriate varieties, but do this within a vibrant cultural context. We accomplish this mission by providing educational resources, mentorship training, outreach and advocacy support on seed policy issues, and organizing national and regional events and convenings to connect many communities who are engaging in this vital work. We are publishing a culturally appropriate toolkit for Seed Sovereignty Assessment. We aim to create a collaborative framework and declaration for ethical seed stewardship and indigenous seed guidelines for tribal communities to guide them as they protect their seeds from patenting and biopiracy. We support the creation of solutions oriented programs for adaptive resilient seed systems within tribal communities to enhance the creative capacity to continue to evolve as the face of our Mother Earth changes.

ISKN is a shade tree of support to the essential work of regional and tribal seed initiatives. We offer a diverse array of resources aimed at nourishing and supporting a vibrant indigenous seed movement as a complement to the growing Food Sovereignty movement within Indian country. In honor of the grand lineage of Seedkeepers who have faithfully passed down seeds for our nourishment, we make restored commitment to care for these precious seeds for those yet to come.

Kristyn Leach, Namu Farm/Second Generation Seeds

For the past five years, my farm has acted as the trial farm for Kitazawa Seed Company, based in Oakland, California. Through performing trials for many beloved varieties of Asian herbs and vegetables, while simultaneously getting involved in organizing around the need for seeds designed and suited for organic systems, I was able to better understand the situation facing Asian-American communities (both plant and human). I began to see the ways that our robust food traditions, farming knowledge, and biodiversity were deeply entangled with free market neoliberalism and increasing dependence on chemical fertility. In order to increase access to open-pollinated varieties of Asian cultivars, and improve seeds for low-input farming systems, Kitazawa has supported me in trying to engage diverse stakeholders in re-imagining a more equitable food system that would incentivize increased seed-saving efforts by small scale API growers. My work is particularly focused on crops who are of notable

value to Koreans and Koreans in diaspora, and the Korean context is the one I feel most comfortable speaking to in this paper.

Background

The Republic of Korea (ROK) is the 6th largest consumer of US agricultural exports. In 2006, preceding negotiations for the Korea-US Free Trade Agreement, US agriculture exports to Korea totaled $2.85 billion. Following the implementation of KOR-US FTA in 2012, that figure rose to $6.03 billion. KOR-US FTA also increased the number of goods that could be imported into Korea duty-free to 80% from 13%.

With the economic growth and restructuring experienced by the ROK, outcomes mirror other countries and regions impacted by the Green Revolution: decline in food self-sufficiency, conversion of rural labor to industrialized jobs, and consolidation of small-scale farms. The percentage of the GDP held by the agricultural sector went from 27% in 1970 to 3.3% in 1999.

In the midst of globalization within the ROK, Seminis acquired Hungnung Seeds, a primary vegetable seed company within Korea. They currently control about 45% of the Korean seed market. Much of the breeding work within the country reflects broader economic trends, with an emphasis on high yielding varieties designed to compete with cheaper imported foods, and increased production of commodities for export. They prioritize larger, industrialized production systems, and do not reflect a valuing of small scale farming.

The increasing pressures felt by Korean farmers, the rates at which farmers are displaced from their lands, and the dramatic depletion of open-pollinated, non-proprietary lines of plant genetics has deeply informed the purpose and principles of this project. While there has been more import of Korean seeds within the past few years, much of the seed is treated and unable to be grown in organic systems. The correlation between trade liberalization and ruptured regional food systems is not unique to Korea, and many diasporic Asian communities have experienced similar things. The desire to preserve cultural relevant food traditions has helped to develop an imperative for seed preservation. We see seeds as both product and lever for the types of food systems we wish to cultivate.

Our goals

- Work within API communities to identify significant crop varieties and their corresponding histories
- Strengthen networks of API growers to incorporate participatory seed breeding projects on their farms that strive to improve open-pollinated cultivars for small-scale, low-input farming systems
- Develop marketing channels to create awareness of distinctions between Asian crops and create economic opportunities for API growers
- Address public health and food security disparities through increasing access to fresh produce tied to cultural foodways
- Explore potential ways for our seed efforts in the U.S. to support farmer led food sovereignty efforts abroad

Kitazawa turned 100 years old this past year, and working in tandem with them allows us to piggyback on the trust they have built with Asian-American farmers and gardeners. Our immediate projects focus on building a website to highlight diverse voices and perspectives of API communities. This includes

detailed growing information about different crops, culinary information, and a forum for people to connect with one another. There are few English language resources available about Asian vegetables that were identified as a barrier for many second generation and beyond folks. We also hope that the Second Generation Seed line will provide a potential market opportunity for farmers to incorporate seed production into their farms. We have released two OP chile pepper varieties to their catalog, with plans to roll out several other crops within the next three years.

Primarily our work has been centered in central California. The past few years have been spent building relationships with farmers, chefs, retailers and distributors, as well as community organizers. While increasing the commercial availability of different varieties has been one part of our project, much of it focuses on non-commercial distribution of seeds and education.

Owen Taylor, Truelove Seeds

The Truelove Seeds catalog launched in December 2017 featuring the fruits (well, seeds) of collaborations with dozens of small-scale rural and urban farmers committed to community food sovereignty, cultural preservation, and sustainable agriculture. More than a seed company, this community seed project emerges organically from roots in food justice work, and aims to deepen that work through seed keeping.

For 15 years, I have worked with food justice organizations, first briefly in the San Francisco Bay area, and then in New York City and Philadelphia. I have worked in diverse communities – prioritizing resources for communities of color – and my roles have included training farmers, gardeners, community chefs, and food activists to be effective educators; building collaborative farmer networks; and community organizing and coalition building around legislative change related to urban farming. In these roles, I have built strong relationships with and gained deep knowledge and skills from community leaders – elders in particular. Over the years, I have been doing more and more anti-racism work with other white-identified folks, both in a food and farming context, and beyond.

For four years, I managed William Woys Weaver's historic Roughwood Seed Collection in Devon, Pennsylvania, which comprises about 4,000 varieties of heirloom food plants, and that was begun informally in 1932 by Dr. Weaver's grandfather H. Ralph Weaver. Around the same time, I was an active member of a Seed Keepers Collective, which is a People of Color led seed saving group that amplifies our communities as keepers of culture, knowledge, ancestry, and of the future. Inspired by the mentorship I received from Dr. Weaver around seed saving and storytelling, as well as the solidarity I felt with SKC around collectively honing our crafts of sharing traditions and ancestry as we share seeds, I decided to integrate seed keeping into my farming and food justice communities.

The first step was to focus super locally. Five community-led farm projects in the Philadelphia area got together regularly this year to support each other in our seed keeping work. Each group comes to the table as experts of our own farming communities. Resilient Roots Farm in Camden, NJ, has many members who are elders that came as refugees from Vietnam and who teach the youth how to grow and prepare their traditional foods. The farmers at Novick Family Urban Farm in South Philly are mostly Karen refugees from Myanmar, who also grow their traditional foods and casually save seeds by hand faster and more efficiently than anyone I've seen. Sankofa Community Farm works to learn, teach, and promote self-reliance using the tools of the deep African Diaspora culture of Southwest Phil-

adelphia. They grow an African Diaspora garden, and keep traditional seeds as part of this mission. Urban Tree Connection is embarking on their journey to save seeds and stories of the African Diaspora as part of their well-established community-driven greening and gardening work on previously vacant land in West Philadelphia. Each of these groups produced at least one culturally significant variety for the Truelove Seeds catalog, and I was able to offer mentorship along the way, while also learning with and from each group.

Many farmers from New York, New England, the mid-Atlantic, parts of the Upper South, and beyond also grew ancestral seeds for the catalog. My first question for each grower was "what seed tells your story?" For many, this question was easy and immediate – they already grow many of their cultural crops. For others, and especially (but not exclusively) many white farmers, this was a more difficult question to answer. For me it has been a challenge as well – my Irish, Italian, and Jewish ancestors assimilated into the American project of whiteness several generations ago. I've interviewed my elders, done extensive genealogical research, and studied the foodways of my ancestral homelands to select my seed crops and grow closer to my story. Many groups who have come to this land by choice, by force, or who were here already have experienced great loss of culture, including language and seed. Keeping ancestral seeds is an act of resilience and resistance.

Many of the farmers grow their ancestral crops as part of their mission to provide fresh, healthy, and culturally appropriate food in their neighborhoods. This builds community power and provides healing from the impacts of food apartheid. Leah Penniman of Soul Fire Farm (one of Truelove Seeds collaborating growers) describes food apartheid as "a human-created system of segregations, which relegates some people to food opulence and other people to food scarcity. It results in the epidemic of diabetes, heart disease, obesity and other diet-related illnesses that are plaguing communities of color." The impact of growing fresh food that tastes like your homeland is profound, especially in a community experiencing the effects of food scarcity.

In all cases, whether through their participation in Truelove Seeds or on the ground in their own communities, the farmers tell their own stories, share their own seeds, receive mentorship around seed production, and at best — tap into a network of seed growers who share a mission for food and seed sovereignty.

Keeping seeds is an act of true love for our ancestors and our collective future. It is a practice of freedom.

Ken Greene, Seedshed

Seeds are both agricultural and cultural. They come with genetic stories as well as stories embedded in human experience. When we plant a seed and it begins to unfold we're bearing witness to its genetic story. But many of the other stories, and the ways in which we become part of that story, may feel invisible.

From the beginning I was interested in the stories of seeds. I started the first seed library in the a public library in the country as a way of honoring those stories and protecting seeds through growing a community of seed savers. I didn't set out to start a seed company, but as my seed work developed I felt it was important to see if a seed company could be both socially just and agriculturally ethical.

Two years ago I started Seedshed with Shanyn Siegel to dig deeper into some of the inequities in our seed systems. When we begin to look at seed systems the way we see watersheds and foodsheds, it becomes apparent that there are damns that prevent access to seeds and seed skills. We can start to map where seeds flow freely though communities or regions and where they are blocked. These damns are often the result of systemic injustice — social, economic, environmental, agricultural, racial — anywhere there is concentration of power by a few aimed at controlling food and seed purely for profit.

Whether helping start local seed libraries, establishing farmer-seed cooperatives, working with sacred seeds that should not be commercialized, helping cultural communities like Akwesasne gain seed sovereignty, or working through farmers and chefs to ensure culturally and agriculturally significant open-pollinated seeds are protected through food markets, Seedshed's mission is to share the wonder of seeds in ways that grow community.

The panelists in this session are all addressing the artificial dams that interrupt the flow of seeds into the commons. Each has taken a proactive, community building, and positive approach to solving challenges to seed justice. While some of these injustice topics may be difficult or painful to face, it is important that all corners of the seed movement gain an understanding of how their actions, and inactions, contribute to seed inequities and what steps they can take to be responsible stewards of local, regional, national, and international seedsheds.