Summary

Conservation and Soil Health Practices for Organic Production Systems:
Selecting Crop Cultivars for Organic Production

Crop genetics can play a significant role in efforts to build healthy soils and protect natural resources. Does the crop perform well without large inputs of nutrients, water, and pesticides? Can it emerge, thrive, and yield under minimum tillage? Will it protect and build soil by covering the ground, forming extensive root systems, and leaving ample residues (Figure 1)? While some crops are considered "high residue" (most grains) or "resource conserving" (perennial forages), and others "low residue" and soil-depleting (most vegetables), different cultivars of a crop such as corn or carrot can vary widely in residue production and other traits that impact soil health.

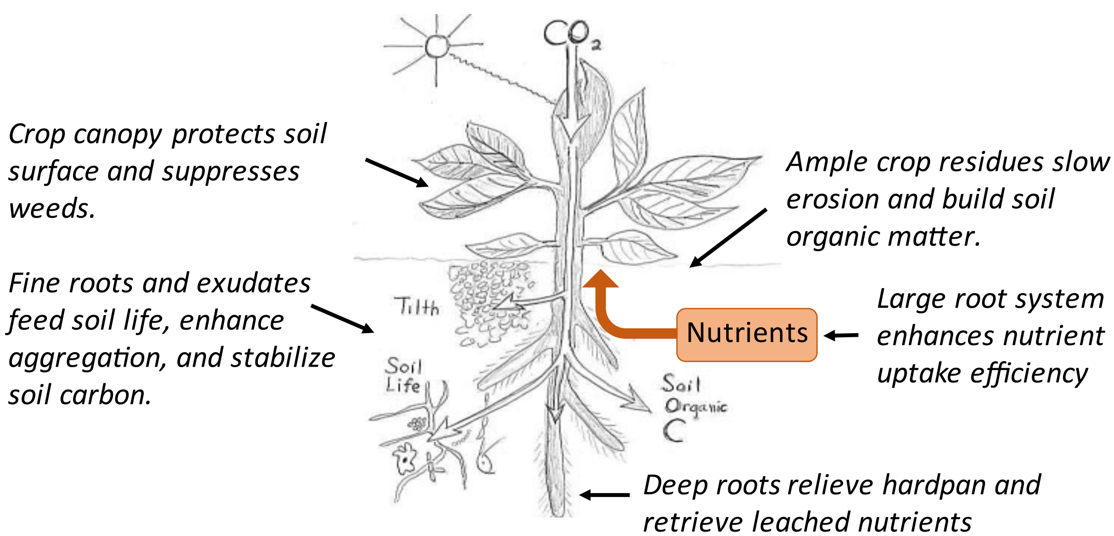

Figure 1. Vigorous cultivars can benefit soil health and water quality.

Organic producers must plant seeds that comply with the National Organic Program (NOP) Standards (see Sidebar). In addition, organic farmers need cultivars that perform well in organic production systems and meet the needs of their customers. Many priority traits for organic crops can help address soil health and other resource concerns (Table 1).

Sidebar:

USDA National Organic Program (NOP) Regulations on Seeds

§205.204 Seeds and planting stock practice standard

"The producer must use organically grown seeds, annual seedlings, and planting stock. Non-organically produced, untreated seeds and planting stock may be used … when an equivalent organically produced variety is not commercially available."

"[Products harvested from] nonorganically produced planting stock … may be sold as organically produced only after the planting stock has been [grown organically for] 1 year."

Seeds must be bred and produced without the use of excluded methods, defined as follows:

"Excluded method: A variety of methods used to genetically modify organisms or influence their growth and development by means that are not possible under natural conditions … [including] recombinant DNA technology."

Traditional breeding, in-vitro fertilization, and tissue culture are allowed.

Table 1. Desired cultivar traits for organic production systems and their benefits to soil health and resource conservation.

Traits	Soil and conservation benefits
Weed tolerance and weed competitiveness	Reduces need for cultivation, protects soil structure and soil organic matter (SOM)
Drought resilience and water use efficiency	Reduces need for irrigation, conserves water resources
Nutrient use efficiency, nitrogen (N) fixation	Reduces need for fertilizer, protects water quality
Rapid emergence and canopy closure, high vigor and biomass, extensive root system	Protects soil from erosion, feeds soil life, builds SOM and soil structure
Disease and nematode resistance	Reduces need for fungicides and nematicides, protects soil life
Enhanced association with mycorrhizal fungi and other beneficial microbes	Increases water and nutrient efficiency, disease resistance, and crop vigor
Ability to emerge, establish, and thrive in organic reduced-tillage systems	Facilitates practices that avoid both physical and chemical disturbance
Cover crops: all of the above, cold hardiness, timely maturity, easy termination.	Facilitates adoption of cover crop practices
Improved yield and overall performance in organic systems	Facilitates organic farming and reduces environmental costs per unit production
Improved market traits – flavor, color, nutritional value, aesthetics, shelf life	Organic farms stay in business and can afford best land stewardship practices.

Challenges in Selecting Crop Cultivars for Organic Production

Over the past 80 years, most plant breeding and selection has been conducted in the context of input-intensive conventional systems that provide soluble nutrients and shield the crop from insect pests, weeds, and pathogens with crop protection chemicals. As a result, modern crop varieties often give lower yields when grown organically with slow-release, biologically mediated nutrient sources, and may fail due to weed competition, pest damage, or disease (Hultengren et al., 2016). The 19% gap between organic and conventional grain crop yields can be attributed to an historical under-investment in research into organic systems, especially the lack of crop cultivars developed for organic systems (Ponisio et al., 2014).

Efforts to compensate for crop genetic limitations with more frequent cultivation, increased nutrient inputs, and copper or sulfur fungicides can thwart efforts to build healthy soil. Organic growers urgently need regionally adapted cultivars with resilience to prevalent diseases, weeds, drought, and other stresses (Hubbard and Zystro, 2016).

Organic producers struggle to find the seeds they need for several reasons:

- Seed industry consolidation has degraded crop genetic diversity, and many heirloom and regionally adapted cultivars have been lost (Shelton and Tracy, 2016).
- Many modern cultivars have been developed with NOP-excluded methods.
- Corporate seed businesses prioritize "big" targets (corn, soy, etc) and do not invest in "minor" crops or regionally adapted cultivars for organic production (van Buren, 2016).
- The public plant breeding sector continues to shrink due to underfunding, and an urgent need exists to train the next generation of plant breeders (Hubbard and Zystro, 2016).
- On-farm efforts to save, select, and improve crop seed are constrained by intellectual property rights (IPR) restrictions on many modern cultivars.

A growing network of plant breeders and seed savers including farmers, non-governmental organizations, and university and USDA scientists are working to restore crop genetic diversity and to address organic farmers' needs for a diverse and resilient seed supply. Farmer innovation, supported by fair access to crop germplasm can help realize these goals (see Sidebar and Farm Story).

<u>Sidebar</u>:

Conserving and Sharing a Vital Natural Resource: Crop Genetic Diversity

Farmer breeders and seed savers working with scientists to develop improved cultivars for organic production systems play a central role in conservation of the world's plant resources.

> *"Dozens of farmer-bred varieties are currently offered in organic seed catalogs."* (Hubbard and Zystro, 2016, p 21)

"More than 70% of the organic seed research projects … involved farmers. One researcher shared, 'We could not do this project without [farmer] involvement. Helpful is not a strong enough word. They are required partners.'" (Hubbard and Zystro, 2016, p 26)

"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." (Open Source Seed Initiative)

"I wish my work to be shared, not monopolized." (Morton, 2016)

The open-source approach allows farmers to select and develop land races for their sites, but it may not provide the financial support that farmers or other plant breeders need to develop and refine cultivars for wider use. Other approaches include a reasonable royalty on plant sales to support ongoing breeding, and the Plant Variety Protection Act (PVP) that allows growers to save seed for their own use but not resale. Unlike utility patents, PVP allows anyone to use the cultivar as a genetic resource to develop new lines.

Farm Story

Developing Climate-resilient Crops

Brett Grohsgal of Even' Star Organic Farm in Lexington Park, MD (Western Shore) has turned the increasingly erratic weather of climate change into a powerful tool for breeding highly resilient land races of arugula, kale, tomato, and other vegetables (Grohsgal, 2017 and 2019). Using the technique of Recurrent Mass Selection (RMS) for winter greens, he starts with large populations grown through the winter outdoors without protection. Each year, seeds are collected from individual plants that emerge on limited fall moisture, survive single-digit nights and sudden spring freezes, grow through erratic temperature swings without bolting, and maintain good yield and quality. Fertility inputs are kept low to select for nutrient efficiency. After two decades of selection, Brett has developed winter-hardy land races of arugula, kale, and Asian mustards that yield high quality greens without protection and draw robust demand from CSA members and restaurant chefs.

For summer vegetables such as tomato, increased and shifting disease and pest pressures add to the direct stresses of adverse weather. Brett has used RMS to build resilience to the whole gamut of climate challenges, allowing events such as the record rainfall of 2018 to takes out all but the hardiest individuals. Starting with a three-way cross followed by years of RMS, he developed 'Gold Star Cherry' tomato that continues to yield top-quality fruit into October while other cultivars finish by late August. He has also improved favorite heirloom cultivars through RMS without initial hybridization. While some scientists consider RMS slower and less precise than pedigree breeding or genetic engineering, Brett has shown that the severe "screening" imposed by unpredictable natural events during RMS simultaneously improves many traits including heat, cold, drought, and disease resilience and nutrient efficiency while he selects among the survivors for yield, quality and flavor. In addition, RMS is more practical for farmers than other methods, and may yield more stable improvement than precision genetic manipulations.

OREI Support for Public Cultivar Development

The USDA Organic Research and Extension Initiative (OREI) has established plant breeding as a program priority:

> *"Strengthen organic crop propagation systems, including … plant breeding for organic production conditions, with an emphasis on publicly available releases. Goals … include, but are not limited to: disease, weed, and pest resistance; stress tolerance including resilience to drought, flood, and disrupted seasonal patterns resulting from climate change; nutrient use efficiency; performance in soil-improving and climate-friendly systems such as organic no-till; quality and yield improvement; and genetic mechanisms to prevent inadvertent introduction of GMO traits through cross-pollination. This priority includes cover crop breeding for enhanced performance in organic systems."* (2021-22 OREI Request for Applications, page 6).

Over the past 15 years, OREI has funded several long-term endeavors to develop new public cultivars of vegetable, specialty grain, and cover crops for organic producers. These projects engage farmers in identifying breeding goals, on-farm breeding, selection, and evaluation, and release of new cultivars; and link university students with farmers for hands-on plant-breeding experience (Dawson et al., 2020; Filmer 2020; Myers et al., 2020; Simon, 2020Thavarajah et al., 2021; Ugarte et al., 2020). Project outcomes include dozens of farmers trained and inspired to continue breeding crops for organic systems, as well as many valuable new cultivars (Figure 2).

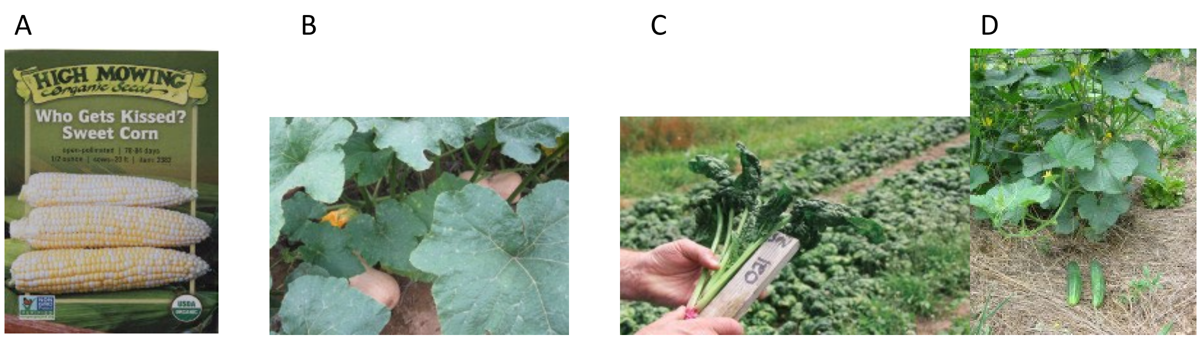

Figure 2. New cultivars for organic systems. A. 'Who Gets Kissed' sweet corn, developed by Drs. Bill Tracy and Adrienne Shelton of University of Wisconsin, Dr. John Navazio, Jared Zystro of Organic Seed Alliance (OSA), and Wisconsin farmer Martin Diffley, features earliness, good cold emergence, disease resistance, and excellent flavor. B. 'South Anna' butternut squash, developed by farmer and plant breeder Edmund Frost of Common Wealth Seed Growers in Louisa, VA, combines vigor and downy mildew resistance with high quality and shelf life. C. 'Abundant Bloomsdale' spinach, developed for the Pacific Northwest by farmers

and OSA, combines flavor and market appeal with cold tolerance and bolt-resistance. D. One of Edmund Frost's disease-resistant cucumber breeding lines that enabled at least one gardener to grow cucumbers for the first time in 20 years.

Selecting Crop Varieties for Organic Production

The collaborative work of organic seed producers, plant breeders, and small, independent seed companies, adds new cultivars for organic systems to seed catalogs each year. Tips to help organic producers find the best seeds for their farm include:

- Start with local and regional seed growers, seed saver networks, and vendors.
- Purchase seed from independent companies that offer heirloom and other cultivars for organic markets, source seed from organic growers, conduct organically managed plant breeding and cultivar evaluation trials, or otherwise serve the organic sector.
- Select cultivars that:
    - Are adapted to the farm's locale climate, soils, and production system.
    - Have been bred and selected in organically managed fields, or that have performed well in organic systems.
    - Emerge and establish rapidly, use water and nutrients efficiently, and have good resilience to locally prevalent diseases and other stresses.
    - Have large canopy, tall stature, high biomass, and deep, extensive roots when these traits are compatible with production system and market needs.
- Conduct simple cultivar trials over several seasons to identify the best performers.
- Participate in on-farm cultivar evaluation, plant breeding, and organic seed production endeavors (see Resources section).

Resources to Help Organic Producers Find or Develop the Seeds they Need

Directory of Organic Seed Suppliers, National Sustainable Agriculture Information Service (ATTRA). https://attra.ncat.org/attra-pub/organic_seed/.

Seed Savers Exchange, https://www.seedsavers.org.

Organic Seed Alliance, https://seedalliance.org/. Coordinates farmer-driven plant breeding and cultivar development, provides farmer training, and holds biennial Organic Seeds conference.

Organic Farming Research Foundation, https://ofrf.org/.

- Soil Health and Organic Farming: Plant Genetics: Breeding and Variety Selection: https://ofrf.org/research/reports/.
- Searchable database of OFRF funded research projects, including over 40 plant breeding and cultivar evaluation projects. https://grants.ofrf.org/.

eOrganic articles and webinars.

- Plant Breeding in Organic Farming Systems, https://eorganic.org/menu/870.
- Carrot Improvement for Organic Agriculture (CIOA) https://eorganic.info/group/7645.

- Tomato Organic Management and Improvement (TOMI) https://eorganic.info/tomi.
- Northern Organic Vegetable Improvement Collaborative (NOVIC) https://eorganic.info/novic/.

Student Collaborative Organic Plant Breeding Education (SCOPE), University of California at Davis CA https://plantbreeding.ucdavis.edu/scope-project. Student plant breeders work with organic farmers from priority setting and concept development through cultivar release.

Student Organic Seed Symposium https://www.soseeds.org/ holds an annual gathering of graduate students, researchers, and farmers to support a new generation of plant breeders who will develop new cultivars for resilient organic systems.

Mandaamin Institute https://www.mandaamin.org/. N-fixing, nutrient-efficient, high-protein grain corn developed from Central American land races.

Research Findings in Plant Breeding and Soil Health for Organic Systems

New cultivars developed with enhanced weed tolerance, nutrient efficiency, and plant-microbe symbioses can make significant contributions to soil health and resource conservation. For example, weed-competitive carrot, wheat, and soybean cultivars generally feature rapid early growth, dense canopy, and season-long vigor (Orf, 2016; Simon et al., 2016; Worthington, 2015). These traits help protect the soil surface and may build SOM through greater residue return. In addition, crops show substantial genetic variation in rooting depth and architecture, and development of cultivars with deep, extensive root systems has been recommended to enhance SOM, nutrient cycling, water quality, and crop drought resilience (Kell, 2011).

University of Illinois has undertaken a participatory testing and breeding program to optimize N use efficiency, yield, and protein quality in organic field corn (Ugarte et al., 2020). Project partner Mandaamin Institute has identified Mexican and Central American landraces of corn with enhanced N use efficiency and a capacity to host N fixing bacteria in the root zone. Today's corn hybrids developed for high-input conventional systems have lost these traits, but crosses with the landraces have successfully re-introduced them. Mandaamin's new hybrids maintain top yields on half the normal rates of fertilizer N, and could thereby protect water quality and greatly reduce input costs (Goldstein, 2015, 2016). In addition, the new lines tolerate drought and perform well in low-fertility soils where standard hybrids fail (Figure 3).

A B

Figure 3. A. A standard variety of field corn grown on a low-fertility tropical soil shows nutrient deficiency stress (left) while Mandaamin Institute's N-efficient field corn maintains vigor (right). B. Ears of corn from standard vs N-efficient corn grown in low-N soil.

Breeding objectives of the Carrot Improvement for Organic Agriculture (CIOA) project include seedling vigor, weed competitiveness, disease and nematode resistance, and enhanced association with beneficial microbes, as well as market traits. Early findings include:

> *"Lines that emerged and formed a full canopy earlier than others resulted in the greatest crop yield in the presence of weeds, as well as the greatest ability to suppress weeds. [S]election of lines that favor early and full top canopy growth can be used as a low input, integrated weed management tool."* (Simon et al., 2016)

The CIOA team has developed breeding lines that combine desired market traits with resistance to the leaf blight pathogen *Alternaria dauci* (Simon, 2020). They have identified a diversity of beneficial root endophytic bacteria that support carrot vigor and blight resistance, especially in organically managed crops. Carrot genotype modulates abundance and efficacy of endophytes, opening an opportunity to select for crop vigor and blight resistance through enhanced plant-microbe partnerships (Abdelrazek et al., 2020; USDA ARS, 2021). Preliminary studies on arbuscular mycorrhizal fungal (AMF) colonization in four carrot cultivars suggest genetic variation may occur. AMF may play an important role in restoring and maintaining soil structure in organic systems that rely on cultivation for weed control (Silva, 2019; Simon, 2020).

The Tomato Organic Management and Improvement (TOMI) project has developed new cultivars with multiple disease resistances (Hoagland, 2019). Tomato cultivars vary widely in capacity to host the beneficial fungus *Trichoderma harzianum* which induces systemic resistance (ISR) to foliar blights, but further research is needed to develop a breeding strategy for this aspect of disease resilience (Jaiswal et al., 2021).

A nationwide endeavor to develop improved cultivars of hairy vetch, crimson clover, and Austrian winter pea cover crops for organic farms has yielded advanced breeding lines undergoing evaluation and seed increase (Mirsky et al., 2020). Breeding objectives include:

- Cultivars adapted to each of the major US agro-ecoregions.

- Rapid emergence, vigor, biomass, and N fixation.
- Winter hardiness and disease resistance.
- Early or late maturity, self-seeding or non-seeding crimson clover for different uses.
- Elimination of hard seed in hairy vetch (to limit weediness).
- Forage quality.

Another breeding objective for soil health is to develop new high-residue income-generating crops for organic systems. Small-scale organic farmers often struggle to maintain soil quality in intensive vegetable rotations as they cannot afford the income foregone associated with cover cropping. Integrating high-residue specialty grains such as spelt, emmer and einkorn wheats, naked barley and oats, millets, grain sorghum, dry peas, and quinoa into intensive rotations can help sustain soil health and farm economic viability. OREI has funded several farmer-researcher teams to develop specialty grain cultivars for organic production (Hayes, 2021; Sorrells et al., 2020; Thavarajah et al., 2021). For example, researchers have evaluated 400 naked barley breeding lines to develop new cultivars with desired culinary traits, weed-competitiveness, disease resistance, and yield under organic management (Hayes, 2021).

Plant breeders at Washington State University have selected quinoa lines for organic production, with heat and disease tolerance as well as high nutritional value. The team has also evaluated root-associated microbial communities for their capacity to fix N, mobilize P, and suppress pathogens, and is preparing to release up to 10 new quinoa cultivars in 2021 (Murphy, 2020).

Graduate students and instructors in the UC Davis SCOPE program announced the release of six new dry bean cultivars for organic systems. Derived from colorful heirloom varieties, the new releases combine resistance to bean common mosaic virus, excellent flavor, and 15 – 60% higher yields than their heirloom parents (Filmer, 2020).

Ongoing efforts to develop a perennial grain has led to commercialization of 'Clearwater Kernza' a perennial wheatgrass that provides both grain and forage (Culman et al., 2020). Although further improvements in agronomic performance are needed, kernza develops several-fold higher root biomass than annual crops, resulting in improved soil aggregation, 2.5-fold higher water infiltration, and reduced potential for N leaching (Sheaffer et al., 2020).

References

Abdelrazek, S., P. Simon, M. Colley, T. Mengiste, and L. Hoagland. 2020. Crop management system and carrot genotype affect endophyte composition and *Alternaria dauci* suppression. PLoS ONE 15(6): e0233783. https://doi.org/10.1371/journal.pone.0233783.

Culman, S. W. L. R. DeHaan, B. W. Ward, V. R. Haden, C. D. Sprunger, R. M. Sulc, M. Ryan, and T. Crews. 2020. *Organic dual-use perennial grain crops: pathways to profitability and soil health.* OREI project 2019-03100.

Dawson, J. C.; M. Colley, A. K. Formiga, and N. Enjalbert. 2020. *Collaborative plant breeding network development for organic systems in the upper Midwest.* OREI project 2020-02247.

Filmer, A. 2020. *UC Davis Releases 6 New Varieties of Organic Beans*. Field trials find varieties Sustainable, High-Yielding and Disease-Resistant. https://www.ucdavis.edu/news/uc-davis-releases-6-new-varieties-organic-beans.

Goldstein, W. 2015. Breeding corn for organic farmers with improved N efficiency/N fixation, and protein quality. Proceedings of the Organic Agriculture Research Symposium. https://eorganic.info/node/12972.

Goldstein, W. 2016. Partnerships between Maize and Bacteria for Nitrogen Efficiency and Nitrogen Fixation. Bulletin 1. Mandaamin Institute, Elkhorn, Wisconsin, 49 pp. http://www.mandaamin.org/about-nitrogenfixing-corn.

Grohsgal, B. 2017. *Winter crop on-farm breeding update: lessons learned after 15 more years.* Growing for Market, February 2017, pp 15-21.

Grohsgal, B., 2019. *Breeding crops for resilience in the face of climate change*. Presentation at Carolina Farm Stewardship Association Conference, November 3, 2019.

Hayes, P. 2021. *Developing multi-use naked barley for organic farming systems.* OREI projects 2017-02470 and 2020-02252.*

Hoagland, L. A. 2019. *Practical approach to controlling foliar pathogens in organic tomato production through participatory breeding and integrated pest management*. OREI project 2014-05405.*

Hubbard, C. and J. Zystro. 2016. *State of Organic Seed*, 2016. Organic Seed Alliance, 112 pp. https://stateoforganicseed.org/.

Hultengren, R., M. Glos, and M. Mazourek. 2016. *Breeding Research and Education Needs Assessment for Organic Vegetable Growers in the Northeast*. http://hdl.handle.net/1813/44636.

Jaiswal, A., Mengiste, T., Myers, J., Egel, D., Hoagland, L. 2020. *Tomato domestication has attenuated responsiveness to a beneficial soil microbe for plant growth promotion and induction of systemic resistance to foliar pathogens*. Frontiers in Microbiology Volume 11 | Article 604566.

Kell, D.B. 2011. *Breeding crop plants with deep roots: their role in sustainable carbon, nutrient and water sequestration*. Ann. Bot. 108(3): 407–418.

Mirsky, S. B. G. R. Smith, J. E. Maul, R. J. Hayes, J. M. Englert, M. R. Ryan, N. J. Ehlke, R. J. McGee, H. Riday, S. Reberg-Horton, and R. Vann. 2020. *Selection to distribution: delivering regionally adapted cover crop varieties to organic farmers.* OREI project 2018-02820.*

Morton, F. 2016. Lettuce breeder, quoted in Fedco Seed Catalog for 2017.

Murphy, K. 2020. *Breeding and agronomy of quinoa for organic farming systems.* OREI project 2016-04408.

Myers, J. W., W. F. Tracy, J. Labate, M. Colley, M. Uchanski,,M. R. Mazourek, and J. C. Dawson. 2020. *Northern Vegetable Improvement Collaborative (NOVIC) 3.* OREI project 2018-02881.*

Open Source Seed Initiative. https://osseeds.org/.

Orf, J. H., T. E. Michaels, M. J. Sadowsky, and C. C. Sheaffer. 2016. *Improving soybean and dry bean varieties and Rhizobium strains for organic systems*. OREI project 2011-01942.*

Ponisio, L.C., M'Gonigle, L.K., Mace, K.C., Palomino, J., de Valpine, P., Kremen, C., 2014. *Diversification practices reduce organic to conventional yield gap*. Proc. R. Soc. B 282, 20141396.

Sheaffer, C. C. D. Wyse, J. M. Jungers, J. M. Grossman, and J. Gutknecht. 2020. *Perennial and annual organic transition systems to optimize soil health, carbon sequestration, and profitability.* ORG project 2017-03405.

Shelton, A. C., and W. F. Tracy. 2016. *Participatory plant breeding and organic agriculture: A synergistic model for organic variety development in the United States*. Elem Sci Anth 4: 000143. https://www.elementascience.org/articles/143.

Silva, E. 2019. Creating climate resilient organic systems by enhancing arbuscular mycorrhizal fungi associations. Organic Farming Research Foundation project final report, https://grants.ofrf.org/node/1637.

Simon, P. W. 2020. *CIOA 2 - carrot improvement for organic agriculture with added grower and consumer value.* OREI project 2016-04393.

Simon, P. W., J. Navazio, M. Colley, L. Hoagland, and P. Roberts. 2016. *Carrot improvement for organic agriculture with added grower and consumer value.* OREI project 2011-01962.*

Sorrells, M.; H. M. Darby, E. Mallory, L. Selman, LA, J. Rutkoski, J. C. Dawson, L. Gutierrez, and J. Malacarne. 2020. *Value added grains for local and regional food systems*. OREI project 2020-02136.*

Thavarajah, D., S. T. Kresovich, and R. I. Boyles. 2021. *Breeding biofortified pulse and cereal crops for US organic cropping systems.* OREI project 2018-02799.*

Ugarte, C. J. E. Andrade, M. M. Wander, A. B. Endres, M. O. Bohn, MA, A. Formiga, AL, and W. Davison. 2020. *Participatory breeding and testing networks: a maize-based case study for organic systems.* OREI project 2017-02413.*

USDA ARS, 2021. *Corralling carrots' microbial allies could stymie disease*. Morning Ag Clips, January 31, 2021. https://www.morningagclips.com/corralling-carrots-microbial-allies-could-stymie-disease/.

USDA National Organic Program (NOP) Regulations. https://www.ams.usda.gov/rules-regulations/organic. ;

Van Bueren, E. L. 2016. *Enhancing Resilience Through Plant Breeding Requires an Integrated and Interdisciplinary Approach*. Pp 133-135 in in Proceedings of the 8th Organic Seed Growers Conference February 4 - 6, 2016, Corvallis, OR. https://seedalliance.org/publications#publication_category_title_13.

Worthington, M., S.C. Reberg-Horton, G. Brown-Guedira, D. Jordan, R. Weisz, and J. P. Murphy. 2015. Morphological Traits Associated with Superior Weed Suppressive Ability of Winter Wheat against Italian Ryegrass. Crop Science 55:50-56.

* Find Organic Research and Extension Initiative (OREI and Organic Transitions (ORG) project reports, by entering grant number on the CRIS Assisted Search Page at: http://cris.nifa.usda.gov/cgi-bin/starfinder/0?path=crisassist.txt&id=anon&pass=&OK=OK.