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PARTICIPATORY PLANT BREEDING AND TRIALING TO INCREASE FARMER CHOICE IN VEGETABLE VARIETIES THROUGH THE NOVIC PROJECT

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Abstract: The demand for organic food in the United States continues to increase at two to three times the rate of demand for non-organic food and a substantial portion of this is organic fruits and vegetables. A comprehensive breeding and seeds system targeted to organic production systems is required to provide the cultivars needed to support increasing demand for fruits and vegetables. Farmers still lack access to a wide array of certified-organic seed and vegetable varieties adapted to organic production. Cultivars that are best adapted to organic production will be those bred under organic conditions. The Northern Organic Vegetable Improvement Collaborative (NOVIC) was implemented to increase the diversity and choice of vegetable cultivars available to organic farmers. It has been funded in three four-year cycles with the project currently in its second year of the third cycle. It is a collaboration of six institutions and over 30 organic farms in six states. The overall goal of NOVIC is to increase the proportion of U.S. agriculture that is managed organically. NOVIC uses participatory plant breeding and participatory variety trialing to understand farmers' needs and conduct breeding efforts. The project has three major initiatives: 1) to conduct vegetable variety trials to identify those adapted to organic systems; 2) to breed vegetable crops where needs are identified; and 3) to provide farmers with the knowledge to produce their own seed and to breed their own varieties. NOVIC has been instrumental in 10 releases of four crops, with another 12 varieties of seven crops in the pipeline. In addition, there are numerous private sector varieties that have undergone evaluation in NOVIC trials. Essentially all of farmers who have participated in NOVIC have indicated that they have changed varieties based on regional trial results. Outreach activities have occurred in about a dozen states through plant breeding workshops and videos and publications are available online.

Introduction: The demand for organic food in the United States continues to increase at two to three times the rate of demand for non-organic food. A comprehensive breeding and seeds system targeted to organic production systems is required to provide the cultivars needed to support increasing demand for fruits and vegetables. Cultivars that are best adapted to organic production will be those bred under organic conditions because of significant genotype by system

interaction (Lammerts van Bueren et al., 2011). Farmers lack access to a wide array of certified-organic seed and vegetable varieties adapted to organic production.

United States Department of Agriculture Organic Research and Extension Initiative (USDA-OREI), has been a significant source of funding for public plant breeding programs (mainly those in the Land Grant University System) for organic plant breeding in the United States during the past two decades (Hubbard and Zystro, 2016). One such project funded by USDA-OREI has been the Northern Organic Vegetable Improvement Collaborative (NOVIC). The overall goal of NOVIC is to increase the proportion of U.S. agriculture that is managed organically, and it was designed to increase the diversity and choice of vegetable cultivars available to organic farmers. Funded from 2009 – 2013 (NOVIC I), and 2014 – 2018 (NOVIC II), NOVIC is now in its third four-year funding cycle (2018 – 2022). NOVIC is a joint collaborative project of six institutions and over 30 organic farms in six states. NOVIC uses participatory plant breeding (PPB) and participatory variety trialing (PVT) to understand farmers’ needs and receive feedback on breeding efforts.

Material and methods: NOVIC partners work with a mixture of vegetable crops that represent a typical farmer’s portfolio (Table 1). Regional project leads have autonomy to work with farmers to choose what crops to trial. The project has three major initiatives: 1) to conduct vegetable trials to identify those adapted to organic systems; 2) to breed vegetable crops where needs are identified; and 3) to provide farmers with the knowledge to produce their own seed and to breed their own varieties (note that in the US, farmers do not have to register cultivars upon release). The variety trials may include both breeding lines developed by NOVIC participants as well as commercial cultivars that show promise for organic production. Farmers in each region also choose a “farmers choice” crop annually (Table 1). For variety trials, we use a mother-daughter trial design (Snapp, 2002). Cornell University leads the effort to breed winter squash and bell peppers, University of Wisconsin-Madison focuses on sweet corn and tomatoes, Organic Seed Alliance in Washington is breeding cabbage, and Oregon State University leads the effort on developing late blight resistant tomatoes (Table 1). We provide farmers with the tools to conduct and analyse their own breeding programs and maintain their own seed, through regional workshops and online videos and bulletins. We also train the next generation of professionals in organic agriculture by providing opportunities for undergraduate and graduate students to work in the regional programs.

In all regions, we conduct needs assessments with farmers, seed producers and other stakeholders about their critical varietal traits and needs. In each region, farmers and seed producers and others in the food trade participated in field days, where variety trials are on display both at research farms and in farmers’ fields. At winter meetings, this same group of stakeholders has been invited to listen to trial results and participate in selection of entries for next years’ trial and the selection of a crop for a farmers’ choice trial.

Table 1. Breeding and trialing activities in Northern Organic Vegetable Improvement Collaborative (NOVIC) 3 to develop open-pollinated varieties adapted to meet the needs of organic growers.

Crop	Breeding/trialing objective
Tomato	Late blight resistance & high tunnel production
Cabbage	Smooth red & green cold tolerant storage types
Bell pepper	Early, high yielding blocky w/ good flavor
Sweet corn	‘Everlasting’ OPs w/ cold tolerance & flavor
Savory corn	Non-sweet vegetable types
Cucumber	Fertile gynococious inbreds
Winter Squash	Long storing butternut types
Farmers’ Choice	Varies by year & region (trialing only)

Results: Overall, NOVIC has been instrumental in 10 releases of four crops, with another 12 varieties of seven crops in the pipeline. In addition, there are numerous private sector varieties that have undergone evaluation in NOVIC trials. For example, NOVIC peppers trials were instrumental in bringing Wild Garden Seed’s Italian sweet peppers to national attention.

Outreach activities have produced more than 17 papers including five refereed publications, seven theses and a number of presentations at professional meetings. More than 65 outreach events for stakeholders have been conducted in partnership with eOrganic, the project group developed and maintains a database of published organic variety trial results. The NOVIC project was among a select set USDA funded grants that was invited to present at a science fair for national legislators in Washington DC in 2017 and to a symposium showcasing successful and productive projects at the American Society of Horticultural Sciences meeting in 2018.

Eight graduate students at three institutions have worked on the NOVIC projects and have graduated, and in most cases, have become part of the organic seed and breeding community. An additional five graduate students are currently in the program or have recently completed.

Discussion: The NOVIC model of PPB and PVT has had a profound influence on the vegetable cultivars that are available and used by farmers. Almost 100% of farmers who have participated in NOVIC have indicated that they have changed varieties based on regional trial results. Over the three rounds of NOVIC, our design methodology for PVT continues to change. Initially, it was primarily researcher-led but has evolved to more of a farmer-led approach (Table 2). The type of data we collect has also changed from quantitative to more qualitative data. We are in the process of assessing how this may relate to farmers’ choice of cultivars based on this data.

Table 2. Evolution of farmer participatory research in the Northern Organic Vegetable Improvement Collaborative (NOVIC) project.

Project	Trial design	Variety selection	Sourcing seed	Transplant production	Planting	Culture	Evaluation	Harvest	Presentation	Publication
NOVIC	R	F, R	R	R	F, R	F	R	R	F, R	R
NOVIC 2	F, R	F, R	R	F, R	F, R	F	F, R	F, R	F, R	R
NOVIC 3	F, R	F, R	R	F	F	F	F, R	F, R	F, R	R

F = farmer; R = researcher

NOVIC has provided the impetus for other initiatives supporting organic plant breeding. One of our NOVIC co-project directors (Mazourek) is a partner in Row 7, a new seed company that works to create new opportunities for certified organic seed produced in the US. Another initiative arising from NOVIC has been the Culinary Breeding Network (CBN) – an effort to link plant breeders and farmers in the organic community with chefs to explore the boundaries of contemporary

seed to table cuisine. One of the main activities of the CBN has been an annual Variety Showcase, where plant breeders with their new and/or unusual varieties are paired with chefs, who develop innovative foods with these materials. Initially held in Portland, Oregon, events have also been held in Hawaii and New York City.

Overall, NOVIC has provided a significant boost to organic vegetable breeding, ultimately with beneficial impacts on farmers’ production systems. One key has been to retain a flexibility to the project that can evolve to best meet stakeholders’ needs. Going forward, a major emphasis will be to finish and release varieties that are currently in the pipeline. In terms of farmer participation, a new activity is to invite farmers into breeders’ nurseries during early to mid-generations in the breeding process to foster communication. We also have activities in sweet corn to develop

“everlasting open pollinated (OP’s)” – varieties that have similar advantages to F₁ hybrids, but do not have the maintenance requirements of OPs and for which seed may be saved for several generations.

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