Organic Participatory Plant Breeding Toolkit: Tools and training in participatory breeding projects for researchers and organic farmers.

Final Report

1. Project Summary

Organic farmers need crop varieties that are adapted to the challenges of organic systems, varieties that can better access organic fertility sources, compete with weeds, and resist pests. Currently, however, almost no plant varieties have been bred specifically for organic systems. To increase organic farmers' success, we must increase the number of varieties bred for organic systems.

Participatory plant breeding (PPB) is a highly effective breeding method and a method that is well suited to organic systems. PPB involves a close collaboration between farmers and researchers, with much of the breeding work often done in the farmers' fields. It enables farmers to select and adapt crop varieties to the specific environmental conditions of their regions and to the organic cultural practices that they use.

PPB can successfully leverage the strengths of all participants. However, many PPB projects are challenged by a lack of clear planning and communication. Farmers and university or industry-based breeders are experts in their own fields, but may not have training in how to methodically assess the needs and capacities of all partners, how to work together in project planning, or how to maintain clear and timely communications.

To foster more successful organic PPB projects, we have created a breeding toolkit. The toolkit includes a background on PPB, planning worksheets, participant needs and capacities worksheets, and case studies from PPB participants. The toolkit has been disseminated at the 2012 Organic Seed Growers Conference (OSGC), through Organic Seed Alliance (OSA)'s website, and will continue to be disseminated at additional events. Participatory breeding and participatory research workshops were presented at the OSGC and through eOrganic.

2. Introduction

Participatory plant breeding is a form of participatory research that involves scientists and farmers working collaboratively in the breeding process. While the practice of participatory plant breeding is relatively new, the achievements of both scientists and farmers in the field of plant breeding are extensive and, in the case of farmers, date back to prehistoric times. Crops such as barley and wheat were domesticated by humans over 10,000 years ago and farmers have been selecting seeds and improving varieties in their fields ever since (Cox, 2009). The rediscovery of Gregor Mendel's genetic experiments in 1900 sparked the interest of researchers in breeding and resulted in a tremendous proliferation of new crop varieties, often

developed from the traditional land races that had been originally bred by farmers (Kloppenburg, 2004).

As researchers began to generate an extensive body of quantitative theory and statistical applications for plant genetic improvement, farmers increasingly have abdicated their role as breeders to those formally trained in the discipline. As a result, the breeding that once occurred mainly in farmers' fields now takes place at university and private company research stations. These research stations, often situated on fertile, uniform agricultural land with intensive application of nutrient and water inputs, allow plant breeders to minimize field variation and increase the precision of selection on genetic traits (Atlin et al., 2001). This environment, however, does not allow for the testing of variety performance under stressed conditions such as weed and insect competition or limited water availability. An urgent question for organic farmers is how will the varieties bred on a research station perform when grown in the unique environment of an organic farm?

Participatory plant breeding has emerged in recent decades with the recognition that farmers and researchers working collaboratively can address this question. Plant breeders in the developing world pioneered this process by moving away from the breeding stations and into the farmers' fields to develop varieties adapted to marginal growing conditions (Pixley et al., 2007). This shift back to farmers' fields has allowed farmers to re-engage with the breeding process. Rather than treating farmers as the end users of their product, participatory plant breeders work collaboratively with farmers in various stages of the breeding process. This includes setting goals, forming breeding populations, implementing effective selection methods, and releasing new varieties. Participatory plant breeding around the globe has markedly enhanced adoption of new varieties by prioritizing locally important characteristics, performance in marginal production environments, and unique quality traits (Weltzien and Christinck, 2008).

In the United States and Europe, the participatory breeding process has only recently been adopted by some practitioners but has already emerged as a model suited for developing varieties for organic and low external-input systems (Dawson et al., 2008). Research indicates that cultivars that perform well in conventional systems are not necessarily high performers in organic systems (Reid et al., 2011; Murphy et al., 2007). Participatory approaches allow breeders to take advantage of the unique soil conditions and management practices found on organic and low-external-input farms. By making selections in the target environment, varieties can be developed with the specific adaptations necessary to thrive under organic production systems. Examples of adaptations for organic production include varieties with disease resistance, seedling vigor to out-compete weeds, and foliage that deters insects.

Sharing their unique yet complementary skills, farmers and breeders engaged in a participatory process are able to realize breeding goals that would be difficult to achieve on their own. While plant breeders tend to draw from populations found in

their own collections or available through the USDA, farmers can contribute plant genetic material from varieties that they have found to be adapted to their particular environment. Because farmers are engaged throughout the entire breeding process, they have the opportunity to articulate the importance of certain traits that might otherwise not be evident to a breeder more familiar with conventional agriculture (Dawson et al., 2008; Weltzien and Christinck, 2008). Varieties developed in this way have a stronger likelihood of being accepted and used by the larger community (Witcombe et al., 2005).

Participatory plant breeding has another central focus, and key benefit, which is education. Farmers gain knowledge and skills in plant breeding and researchers gain insights into farmer priorities and novel crop traits that are important to specific client groups (Snapp, 2002). Sometimes called "client-oriented" breeding, this approach has the explicit goal of empowering farmers to engage in on-farm experimentation (Dawson et al., 2008). Through the project, farmers gain a wide range of research skills that can be utilized after the project has ended (Weltzien and Christinck, 2008). Educating farmers and other stakeholders about successful breeding strategies for participatory breeding processes is a goal of this toolkit and a long-term benefit arising from a participatory approach.

The challenges of participatory breeding, however, are substantial and important to consider. According to Vernooy et al. (2009), the start-up periods for collaborative research projects are time and labor intensive, requiring commitment to develop communication and quality relationships. Quality relationships are crucial to a successful collaborative project and their importance cannot be overstated. Because many stakeholders are involved in the project, the likelihood of different approaches, modes of communication, and unexpected challenges emerging over the course of the project is high. Thus, building quality relationships and developing a common framework of shared goals is critical (Snapp and Heong, 2003).

The model requires participants to be invested in the process as much as in the outcome, to be flexible, and to communicate clearly with one another. Issues can also arise regarding intellectual property rights when a new variety is bred. Because both the farmer and breeder have invested time and resources into its development, the questions of who owns the variety and who may profit from its sale must be considered before the commercialization stage is reached. Sections of the toolkit are designed to help you effectively navigate these challenges in order to create a successful participatory plant breeding project.

The practice of on-farm plant breeding using PPB addresses several high priority organic farming issues. First, it enables the farmer to adapt crop varieties to the specific environmental conditions of the region in which they are bred. Much of the seed that it currently sold is bred for use on prime agricultural land with ample external inputs in large-scale, centralized production areas. Most of the diversified organic farms with a strong commitment to ecological agriculture practices in North America are not on prime agricultural land in the centralized, prime agricultural

zones. Secondly, PPB allows the farmer breeder to select and adapt the varieties that they are breeding to the organic practices being used on their farm, such as cool soil emergence and weed competitiveness.

For all of its benefits in breeding for organic agriculture, PPB also comes with a set of unique challenges. Through our own work and through our conversations with PPB participants, we have seen that many PPB projects are challenged by the complexity of planning and communication required. Farmers and university or industry-based breeders are experts in their own fields but may not have training in how to methodically assess the needs and capacities of all partners, how to work together in project planning, or how to maintain clear and timely communications. PPB is part of the solution for bringing organically adapted varieties to market, and this breeding toolkit will increase the success of PPB projects.

3. Objectives Statement

Our primary objective was to provide education and tools for farmers and researchers to succeed in participatory organic plant breeding projects.

We accomplished this objective by creating a breeding toolkit to aid in planning and executing organic PPB projects. The toolkit includes project blueprints, planning worksheets, participant needs and capacities worksheets, and case studies from PPB participants. We distributed and advertised the toolkit via high-impact events and websites including the 2012 Organic Seed Growers Conference (OSGC), OSA field events, eOrganic and seedalliance.org.

Additionally, at the OSGC we presented a Participatory Plant Breeding World Café workshop, where farmers and researchers discussed the successes and challenges they had with their PPB projects. A draft toolkit was distributed at the Café and its contents were reviewed by participants. Finally, co-author Sieg Snapp hosted a webinar on participatory research via eOrganic where the toolkit was discussed.

We have assessed the success of this project by the number of toolkits distributed, the number of attendees at the panel session, and the number of times the toolkit was downloaded.

By providing a toolkit to simplify the PPB project planning process and guide the discussions of the participants, we expect that this project will increase the success of organic plant breeding projects, leading to more and higher quality varieties bred for organic agriculture.

4. Materials and Methods

This project consisted of a written toolkit in conjunction with presentations on participatory plant breeding.

To develop the toolkit, we expanded the author team to include Sieg Snapp from Michigan State University, a leading expert on participatory research, and Adrienne Shelton from University of Wisconsin, a graduate student studying participatory plant breeding.

The authors began with an extensive review of the current literature on participatory breeding, distilling the most important lessons relating to both PPB theory and the practical application of PPB. Much of the work in PPB has been done internationally, so we adapted many of the procedures to fit a domestic context.

In preparation for writing the toolkit, we interviewed farmers and researchers who have engaged in PPB projects, asking them about successes, challenges and lessons learned. Additionally, all of the authors have experience with participatory research. We took the lessons from our own work and from the interviews and used them to develop planning processes that simplify and strengthen the participation of all the members of a PPB project.

In order to get input from a broad array of farmers and researchers, we distributed 100 copies of a draft of the toolkit at the Organic Seed Grower's Conference during the Participatory Plant Breeding World Café session (see below). Each of these copies included a request for specific feedback and input. From this, we received additional input on how to strengthen and clarify the toolkit and make it more useful to people engaging in PPB projects.

The presentations consisted of a Participatory Plant Breeding World Café workshop session presented by Jared Zystro, Sieg Snapp, Frank Kutka, and Adrienne Shelton and a participatory research webinar presented by Sieg Snapp. The PPB Café featured roundtable discussions on four participatory research topics, allowing participants to rotate. The topics were: an introduction to farmer participatory research; participatory breeding methods; participatory breeding in vegetables; and the Farmer Breeder Club's participatory approach to breeding and trials. The webinar presented approaches and methodology for conducting research on-farm and developing relevant technologies in partnership with organic and sustainable farmers.

5. Project Results

Present your project results. Quantitative results (numerical and/or statistical data) and qualitative results (descriptions of how well or poorly something worked) are both important. Tables, graphs and other figures representing your data are excellent ways to summarize data and present them in an accessible way.

Toolkit:

The toolkit was published in June 2012. It is 55 pages long and the contents of the toolkit are:

Participatory Plant Breeding Theory

- Participatory Research Overview
- Development of Participatory Plant Breeding
- Participatory Plant Breeding for Organic Systems
- Benefits and Challenges of Participatory Plant Breeding

Participatory Plant Breeding in Practice

- Why communication and planning matter
- Crafting the project's goals
  - Verbalizing implicit goals
  - Prioritizing goals
  - Setting realistic goals
  - Balancing conflicting goals
- Target environments
  - Broad vs. narrow adaptation
- Selection criteria
  - Prioritizing selection criteria
  - Measurability
  - Heritability
  - Germplasm
- Trial design
  - Field effect
  - Consistent treatment
  - Population and plot size
  - Border rows
  - Marking and mapping the trial
  - Balancing trial needs and farm needs
- Resources
- Roles and responsibilities
  - Project management
  - Fund-raising
  - Financial management
  - Sourcing germplasm
  - Designing the breeding plan
  - Making cross pollinations and controlled pollinations
  - Evaluating / selecting materials
  - Harvesting, storing, and managing the seed
  - Growing populations and trials
  - Reproducing seed
- Planning a timeline
- Communications
- Scheduled Communication
  - Planning meeting
  - Kickoff
  - Annual / semi–annual meeting
  - Calendar of key events

Unscheduled communication

Case studies
Case Study 1: Corn
Case Study 2: Broccoli
Case Study 3: Wheat

References

Other resources
Seed saving
Participatory research
Plant breeding
On-farm research

Worksheets
Worksheet 1: Project Goals
Worksheet 2: Traits
Worksheet 3: Resources
Worksheet 4: Project Timeline
Worksheet 5: Annual Timeline
Worksheet 6: Trial Plan

Presentations

Two presentations were held in conjunction with this project: the PPB World Cafe at the Organic Seed Grower's Conference and the participatory research webinar.

6. Conclusions and Discussion

By producing a comprehensive yet accessible toolkit for participatory plant breeding projects, this project will benefit both farmers and researchers who are involved in PPB. The feedback we have already received for the toolkit has been overwhelmingly positive. By getting early feedback on the toolkit from attendees of the Organic Seed Growers Conference (OSGC) and by hearing about specific concerns about PPB from attendees of the PPB World Café session at the OSGC, we were able to adapt the final toolkit to best fit farmers' and researchers' needs. For example, we received feedback about the need for more extensive resource lists, and so we expanded the resource list in the toolkit to include not only information on PPB but also information on general plant breeding topics, on seed saving, and on variety trials.

The field of PPB is rapidly growing in the U.S. and this toolkit comes at the right time. If we wrote this again at a later time, we would expect to see more resources and more examples of projects. At OSA, we anticipate updating the toolkit at a later date to take advantage of new information.

The PPB toolkit provides a background in PPB and practical steps to successfully execute PPB projects, along with case studies and worksheets. Although it touches on basic plant breeding procedures, that is not its focus. As a next step in developing tools to engage organic farmers in plant breeding, OSA is developing an introductory organic plant breeding manual and crop specific organic breeding manuals for carrots, tomatoes, and sweet corn. These will be available in late fall of 2012.

7. Outreach

We distributed 100 draft copies of the PPB toolkit at the Organic Seed Grower's Conference. We are printing the final version now and intend to distribute over 200 more at additional events and through direct contact with farmers and researchers. In the two weeks since the PPB toolkit was published to the web, over 100 individuals have downloaded it. We expect that that number will be well over the 200 downloads we initially anticipated by the close of the grant period in September.

When the toolkit was completed and made available for download, we sent a press release to about 160 national contacts, including journalists and NGOs. OSA's Facebook press release about the toolkit was shared by our followers 58 times and the post reached 1,926.

Over 40 farmers and researchers attended the World Café. This number was slightly less than the 60 we had anticipated, likely because of a severe snowstorm which prevented many people from attending the conference and the fact that this year the OSGC had 5 workshop tracks occurring concurrently. Over 100 people have viewed Sieg Snapp's participatory research webinar.

8. References

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9. Addenda

Attached (below): Photos from case studies

Attached: PPB Toolkit

Jim Myers and Jonathan Spero (left to right) examining broccoli population (photo courtesy Laurie McKenzie)

Bill Tracy, Martin Diffley, and John Navazio (left to right) evaluating sweet corn families (photo courtesy Adrienne Shelton)