Research brief — An exploration of farmer selection methods and perspectives on participatory plant breeding of organic wheat and oat varieties

April 2024

THE BAUTA FAMILY INITIATIVE ON CANADIAN SEED SECURITY

A program of

SeedChange

In collaboration with

Carleton University

An exploration of farmer selection methods and perspectives on participatory plant breeding of organic wheat and oat varieties

Authors

Helen Jensen (SeedChange), Iain Storosko (Carleton University), and Michelle Dang (SeedChange)

Background

Participatory plant breeding (PPB) is a breeding methodology that creates the opportunity for farmers and researchers to work together to develop crop varieties adapted to local environments and suited to the particular needs of farmers. In 2013, The Bauta Family Initiative on Canadian Seed Security partnered with the University of Manitoba in creating the first ever national PPB program in Canada to develop wheat and oat varieties with organic farmers. There is not strong data related to farmer selection practices and farmer perspectives on PPB in Canada. To better understand this, we conducted open, semi-structured interviews with 19 participating organic grain farmers to address the following research questions: (1) What methods do farms use to select for desired crop traits and why are these methods used? (2) What strengths and limitations do program participants face in Canada? (3) How do participating farmers perceive PPB in the broader context of organic agriculture in Canada?

Results highlights and major takeaways

- Grain size was given the most focus in the Prairies and British Columbia (BC), while Ontario farmers focused more on agronomic traits related to production (like straw height strength) and Quebec farmers focused more on disease resistance. The Maritimes farmer selected for a combination of production, yield, and disease resistance traits.
- Farmers most often made positive selections, followed by negative, blended positive and negative, and “natural selection.”
- The most frequently mentioned PPB program strength was the collaborative network of farmers and researchers that allows for knowledge sharing, access to resources, and agronomic support.
- The major limitation of PPB mentioned by farmers is the lack of an accessible regulatory system for PPB varieties to operate in to make PPB profitable.
- Farmers perceive the purpose of PPB in Canada through a wide range of themes, including; genetic innovation, seed sovereignty, agricultural resilience, and farmer empowerment.
- The differences in selection methods, selection timing, and agronomic trait selection both within and between regions and farmers demonstrate that farmer

inclusion is necessary in seed breeding and programming to meet the needs of their farms, environments, and markets.
- Farmer-proposed strengths and suggestions for improvement in the existing structure and methods of PPB programs can be used to make PPB more beneficial and sustainable for all stakeholders, especially farmers interested but not yet involved in PPB.

Read the full report here: An exploration of farmer selection methods and perspectives on participatory plant breeding of organic wheat and oat varieties

Introduction

The availability of crop varieties that are well-suited to both low-input, pesticide-free agriculture and regional environmental conditions is important for the continued success of organic agriculture, especially in light of climate change.[1-3] In Canada, few organic farmers have access to crop varieties developed for regional organic farming systems. Participatory plant breeding (PPB) is a method where farmers and formal plant breeders collaboratively produce crop varieties guided by each other's expertise. PPB develops better varieties for organic farming systems by using local farms as breeding environments, but also encouraging farmers to incorporate the needs of their local social, economic, and cultural conditions into variety development.[7-10]

Despite this, PPB and the farmers that participate in it remain under-researched in Canada from both an agronomic and social science perspective. The PPB program managed by the University of Manitoba and facilitated through The Bauta Family Initiative on Canadian Seed Security (BFICSS) ran from 2013-2021. Stakeholders, including farmer participants, researchers, and BFICSS staff continue to collaborate on the material generated from this program. However, the selection methods used by farmers and their perspectives on PPB have not been well defined. Data on PPB selection methods used by farmers can help both farmers and researchers understand how organic farmers select for traits, the strengths and weaknesses of their selection methods with regards to desired traits, and share knowledge on improving the accuracy and efficiency of these selections. Showcasing farmer PPB selections could also inspire other farmers to adopt PPB techniques within their operations or join a PPB program. Further, farmer perspectives on selection priorities can help organizations and institutions in Canada adapt plant breeding programs and policies to better accommodate the needs of organic farmers. Here, we aim to outline the selection methods and perspectives of organic grain farmers that are PPB program participants.

In this study, we address the following three research questions:

1. What methods do farms use to select for desired crop traits and why are these methods used?
2. What are the strengths and limitations that farmers face when engaging in PPB in Canada?
3. How do participating farmers perceive PPB in the broader context of organic agriculture in Canada?

Figure 1. A farmer-breeder from the participatory plant breeding program conducting selections on wheat crosses on his organic farm in Manitoba, Canada. (Photo: Helen Jensen)

Methods

We invited all PPB program participants via email to take part in this study. From this, we included 19 program participants in the study from regions across Canada (see demographic breakdown in Table 1). We conducted interviews by telephone from June - December 2020. We interviewed participants in an open interview format, semi-structured, which involved being prompted from a list of set questions to explore their opinions on the function, challenges, and opportunities for PPB in a Canadian context. We also asked farmers about the type and timing of their selection methods during interviews.

Table 1. Frequency of farmer participation and total acreage by region. "NA" denotes data that is not available.

Region	Total	Total acreage
British Columbia (BC)	2	4 - 20
Prairies	7	130 - 4500
Ontario	5	NA - 250
Quebec	4	NA - 1500
Maritimes	1	500

Once all interviews were complete, we gave all participants coded aliases to maintain confidentiality. We then imported the data into Nvivo analytical software and organized data into key themes. We drew limited conclusions about the experiences of Maritimes PPB farmers due to the limited sample size.

Results and discussion

Selection methods

Overall, farmers both within and between regions used a mixture of selection strategies at various times in the growing process to select for an array of agronomic qualities in their grains. Selection methods are based on either positive selection, negative selection, blended methods, or "natural selections." Positive selection targets desired individuals within a population for harvest and retaining them for later potential breeding. Negative selection involves removing undesirable individuals within a population, then leaving those of interest untouched for harvest at the end of the season. Blended selection methods involve a combination of both positive and negative selection used during the same selection season. "Natural selection" involves the entire plant population being left in the fields with minimal management with the expectation that the best adapted plants to local environmental conditions will contribute the most to the genetics of the population. A breakdown of trait selections, selection method, and timing of selection assessments is summarized in Table 2. Farmers in different regions showed regional differences in their selection priorities, which can be seen in Figure 2.

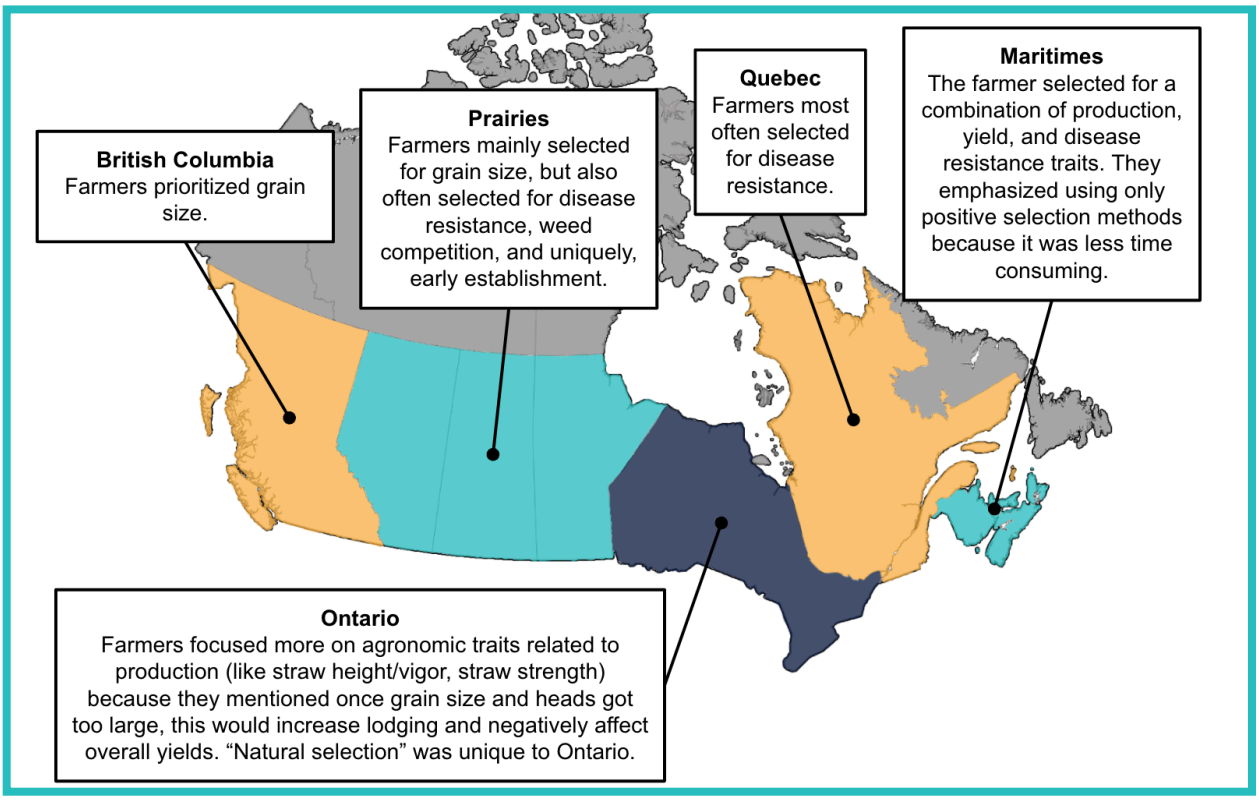

Figure 2. Trends in farmer selection methods and priorities by region. ("Map of Canada with Provinces - Outline" licensed under CA-EPS-01-0005)

Table 2. Breakdown of farmer selection methods and timing of assessments by participant, region, and trait of interest (n = 19). Dashes (-) denote data a trait that was not actively selected and asterisks (*) denote missing data. Legend: yes = selection was made but the selection method is unknown, pos = positive selection, neg = negative selection, nat = “natural selection”, harv = harvest time, pre-harv = pre-harvest, hdg = heading, pre-hdg = pre-heading, pst-hdg = post-heading, stm evt = after storm event, thresh = threshing, cont = continuous assessment throughout season.

	Straw Height/ Vigor		Disease Resistance		Grain Size		Straw Strength	
Farmer ID	**Selection Method**	**Timing**	**Selection Method**	**Timing**	**Selection Method**	**Timing**	**Selection Method**	**Timing**
BCFarmer_A	pos	hdg	yes	hdg	pos	harv	-	-
BCFarmer_B	-	-	-	-	pos, neg	thres	neg	pre-harv
PRFarmer_A	pos	harv	pos	harv	pos	harv	pos	harv
PRFarmer_B	pos	harv	pos	harv	-	-	pos	harv
PRFarmer_C	pos	harv	-	-	-	-	-	-
PRFarmer_D	pos	*	neg	hdg	-	-	-	-
PRFarmer_E	pos	pre-harv	-	-	pos	pre-harv	-	-
PRFarmer_F	pos	harv	pos	harv	pos	harv	-	-
PRFarmer_G	-	-	neg	*	yes	*	-	-
ONFarmer_A	neg, pos	pst-hdg, harv	-	-	neg, pos	pst-hdg, harv	neg, nat	cont
ONFarmer_B	-	-	-	-	-	-	pos	harv
ONFarmer_C	-	-	-	-	-	-	-	-
ONFarmer_D	pos	*	pos	stm evt	-	-	pos	stm evt
ONFarmer_E	pos	*	-	-	-	-	-	-
QCFarmer_A	pos	*	pos	pst-hdg	pos	pst-hdg, harv	-	-
QCFarmer_B	*	*	*	*	*	*	*	*
QCFarmer_C	-	-	neg	harv	neg, pos	hdg, harv	neg	hdg
QCFarmer_D	-	-	neg	*	-	-	-	-
MTFarmer_A	pos	pre-harv	pos	hdg, pst-hdg	-	-	pos	pre-harv

	Yield		Weed Competition		Maturity		Early establishment		Processing quality (threshing)	
Farmer ID	**Selection Method**	**Timing**	**Selection Method**	**Timing**	**Selection Method**	**Timing**	**Selection Method**	**Timing**	**Selection Method**	**Timing**
BCFarmer_A	-	-	-	-	-	-	-	-	-	-
BCFarmer_B	-	-	yes	*	yes	*	-	-	-	-
PRFarmer_A	pos	harv	pos	harv	-	-	-	-	-	-
PRFarmer_B	-	-	pos	harv	-	-	-	-	-	-
PRFarmer_C	-	-	yes	*	-	-	yes	*	-	-
PRFarmer_D	-	-	-	-	-	-	-	-	-	-
PRFarmer_E	pos	harv	pos	pre-harv	-	-	-	-	-	-
PRFarmer_F	-	-	-	-	yes	*	-	-	-	-
PRFarmer_G	-	-	yes	*	-	-	-	-	-	-
ONFarmer_A	-	-	-	-	nat	harv	-	-	-	-
ONFarmer_B	pos	harv	-	-	-	-	-	-	pos	harv
ONFarmer_C	-	-	-	-	-	-	-	-	-	-
ONFarmer_D	-	-	-	-	pos	*	-	-	-	-
ONFarmer_E	-	-	-	-	-	-	-	-	-	-
QCFarmer_A	-	-	-	-	-	-	-	-	-	-
QCFarmer_B	*	*	*	*	*	*	*	*	*	*
QCFarmer_C	pos	harv	-	-	-	-	-	-	-	-
QCFarmer_D	neg	*	neg	*	-	-	-	-	-	-
MTFarmer_A	pos	pre-harv	-	-	-	-	-	-	-	-

The most common traits selected by farmers overall in descending order were:

- **Straw height/vigor**: positive selections were made when crop was fully grown and grain set was complete
- **Disease resistance:** positive selections were made during harvest, or negative selections were made during key crop development stages such as tillering, heading, or grain filling,
- **Grain size:** positive selections were made during harvest, or negative selections were made during heading or post-heading
- **Straw strength:** blended positive and negative selections were made by keeping standing plants in and removing lodged plants at harvest respectively
- **Yield**: assessed and positively selected for during harvest
- **Weed competition:** assessed using positive selection during harvest
- A small number of farmers also selected for **maturity**, **early establishment**, and **processing quality**

The differences in selection methods, selection timing, and agronomic trait selection both within and between regions and farmers demonstrate that farmers have specific traits that they want to see in their seed. Breeding programs that include farmers and let them guide breeding priorities ensures that the seed they grow can meet the needs of their farms, environment, and markets.

Farmer perceived strengths and limitations of PPB in Canada

Farmers outlined a diverse range of strengths and limitations of PPB based on their experience participating in the PPB programs. Table 3 summarizes the major thematic topics farmers outlined in their perceptions on PPB strengths and limitations into categories of scale.

Table 3. Major themes in farmer perceptions of PPB strengths and limitations categorized by scale.

Scale of Integration	Description of Scale	Strengths	Limitations
Farm-level	On the farm and within the daily lives of farmers	• Genetic innovation and seed system resilience • Stories and branding for seeds	• Scheduling plot assessments and time constraints • Limited utility of PPB varieties across regions
Program-level	In the context of the PPB program and facilitators of the PPB program	• Collaboration among farmers, networking, and knowledge sharing • Collaboration with universities, providing technical research capacities	• Lack of capacity for lab-based assessments • Multiple, changing points of contact • Limited access to appropriate machinery
Institution-level	As part of research, governmental, or industrial markets, policies, or groups	• Public research for public benefit • Farmer empowerment to make decisions in research	• Limitations to growth without PPB varieties registration • Lack of proper governmental support and funding

To expand further, the major strengths of PPB mentioned by farmers were:

- **Collaboration among farmers, networking, and knowledge sharing.** Farmers discussed this topic in greater length and enthusiasm than all other strengths. Often organic farmers feel isolated in their individual practices and at a lack of information and resources to approach issues found on-farm. The network of mutual connection and communication facilitates knowledge sharing, as well as access to resources, sharing equipment, and seed stock. The access to university facilities, researchers, and techniques also allows farmers to try new approaches to farming and scale up the varieties of seed they are interested in growing or have crossed. The advice and support received is not always limited to seeds or breeding alone, but on organic agriculture practices in general. The program in many interviews was compared to an agriculture extension service much needed in Canada.

> *"And then now, with this club that's been started up, we can all communicate on the webinar, and chat, and learn from each other. So I think that's another positive outcome of the whole program, is the network that's building between us producers."*
>
> — Participating farmer, Prairies

- **Genetic innovation and seed system resilience.** Some farmers saw this simply as creating genetically improved varieties for organic systems, while others saw an additional benefit of supporting genetic heritage for varieties that got lost in conventional seed systems.
- **Public research for public benefit**. The research process of PPB addressed many more of their concerns as farmers than what would typically be addressed by research programs facilitated by government or industry. The PPB program opens up and democratizes the scientific process in agriculture. Participants believed in the importance of including farmers directly in agricultural research of any kind, and felt empowered to bring forward their opinions and decisions in research.

> *"It holds out to me the hope of a greater appreciation for farming done differently, for organic farming, for cooperative farming, for cooperative marketing, for cooperative branding, in a way that we haven't seen for probably upwards of a generation now."*
>
> — Participating farmer, British Columbia

The major and most frequently mentioned limitations of PPB by farmers were:

- **Lack of capacity for lab-based assessments.** Farmers wish to gain a better understanding of the flavour, nutrient, and consumption qualities of PPB varieties to help drive demand for PPB material; however, access to lab-based assessments to analyze these qualities is limited. This limitation is a result of a lack of program funding and resources to support farmers in this area, but also due to some farmers

having limited amounts of grain they can grow of one variety (for example, not enough seed can be grown out to facilitate a proper tasting trial).

- **Scheduling plot assessments and time constraints.** Time constraints and trade-off with other farm duties made it difficult to make assessments at critical stages during the season. The additional time commitment on-top of farm duties likely is a deterrent for PPB participation among farmers.

> *"I would like to see that Canada recognizes participatory plant breeding as a viable and an important solution to agronomic solutions for environmental change. But it's not even on the radar of most people... We need to engage our farmers in participating in this. But we're not going to see that as long as there's so much control on seed stock."*
>
> — Participating farmer, Ontario

- **Limitations to growth without PPB varieties registration.** The current registration system is a lengthy, expensive, and resource-intensive process that some farmers believe will fall on them. Without any kind of accessible variety registration process, the market price of unregistered PPB varieties may not justify the additional work needed for their ongoing development. This is related to distances between areas.

The question can also be raised as to whether participatory breeding and collaborative research is facilitated adequately by civil society and programs such as the BFICSS, or whether public research institutions could become more involved in research like this? Government-facilitated PPB programs could create more direct funding for farmers and potentially push the regulatory seed system towards being more inclusive of PPB varieties. Alternatively, more universities over a wider geography nationally involved in facilitating PPB could allow for better distribution of costs associated with program operation, as well as create easier access to needed machinery, equipment, lab analysis, and agronomic support for farmers across more regions.

Farmer perceptions of PPB in organic agriculture

Farmers expressed a wide range of perspectives on PPB and its potential purpose on the broader organic agricultural sector. Farmer participants expressed that initially, their main motivations for wanting to participate in PPB were:

- Improved organic production capacities
- Movement towards greater seed sovereignty
- Farmer empowerment in the research and development process
- Support for scientific innovation in Canada
- Increased collaboration and cooperation between farmers and researchers

After participating in PPB, participants expressed that in the context of organic agriculture, the primary values they see in PPB are:

- Reinforced sense of empowerment
- Greater autonomy in farming
- Emphasized role of farmers in food sovereignty
- Democratic model of research
- Increased genetic resources and agronomic tools

The repeated political notion of empowerment was noted across responses, highlighting a shared sense of disenfranchisement and loss of agency within mainstream agricultural research systems. Farmers who participate in PPB mentioned bringing their own voice into seed breeding, research, and the agricultural community, which empowers them to have more autonomy and sovereignty in the broader field of organic agriculture. We saw that farmers viewed PPB as a tool in an alternative, farmer-powered agricultural system that acts in resistance to conventional systems. Studies have shown that PPB can also offer farmers a self-sustaining source of genetically diverse and resilient seed amid changing climate conditions.[11-14]

While the PPB program has made great strides to support organic farmer-led breeding and agricultural systems, these results can be used as momentum to improve the program for current and future participants. This includes continuing to facilitate areas of PPB that have worked well thus far, like the collaboration and knowledge-sharing opportunities, but also improve underdeveloped areas, like agronomic resources or governmental policies for farmer-led breeding in broader organic agriculture.

"One of my favorite things that I love about this program is that it's empowering farmers to do things to help themselves. We're being encouraged to select for lines that work in our region, we're being encouraged to participate in such an important aspect.

Seed is so important, and being able to participate in a program that allows us to strengthen the seed supply in organic agriculture is pretty special. That's a big part of what is motivating me to be a part of the program in the first place, is that whole aspect of empowering organic farmers to be able to make their own choices and make their own seed is really important."

— Participating farmer, Prairies

Figure 3. A "common garden" evaluation of wheat varieties from the PPB program at the University of Alberta, 2021. (Photo: @talonstokesphotography)

Conclusion

This report outlined the PPB selection methods used by organic grain farmers and their perspectives on PPB in Canada. Farmers demonstrated a diverse range of breeding priorities and used various selection methods, timing of assessments, and agronomic traits to breed for seed that meets their agricultural goals and regional needs. PPB can support farmers in using their autonomy, democratic voice, shared agronomic resources, and farmer-research network to facilitate seed sovereignty, farmer-led breeding, farmer-researcher collaboration, and increased capacity for organic agriculture in Canada.

Farmers can use PPB to produce their own regionally-adapted seed which would help farms become more self-sustaining and resilient over time, especially in light of climate change. This study's insights on farmer selection methods can inform future programming to help farmers and researchers accurately and efficiently select for desired agronomic traits (like identifying signs of disease earlier to negatively select against plants with poor disease resistance, or planting crops at an ideal density so that lodged plants can be removed before knocking other plants over). The strengths, limitations, and perceived value of PPB shared by farmers can act as a guide for future improvement for the PPB program, researchers, and government to better support organic farmers and PPB in Canada. While the sample size for this study was small, especially so for some regions, its results act as a great starting point for building a better understanding of the culture around PPB programs in Canada. To support the commercialization of PPB crops, the

BFICSS also published a complementary report that outlines PPB value chains and potentials for future integration, available to read here.

If you would like to learn more about The BFICSS or participate in any of our programming, please visit us at seedsecurity.ca to learn more.

Acknowledgements

We would like to thank the many people who have contributed to this project. In particular, we recognize the contributions of the following individuals: The farmers who have been working since 2013 to develop organic wheat and oat varieties via participatory plant breeding methods and who consented to be interviewed for this work; David Catzel, Iris Vaisman, Tierra Stokes, Rebecca Ivanoff, Aabir Dey, Hugo Martorell and Stephanie Hughes at The Bauta Family Initiative on Canadian Seed Security for their contributions to farmer outreach, communications and knowledge sharing; Professors Peter Andrée and Patricia Ballamingie at Carleton University for their support and advice throughout the project; Murray Jowett and Iain Davidson-Hunt at the University of Manitoba for their work on value chain mapping; Martin Entz and the Natural Systems Agriculture Lab at the University of Manitoba for his leadership in developing the participatory plant breeding program.

This research was made possible by a grant from the Organic Farming Research Foundation (to H. Jensen) and a MITACS Accelerate internship grant (to I. Storosko). This project is also funded in part by the Government of Canada through Agriculture and Agri-Food Canada's Canadian Agricultural Strategic Priorities Program (CASPP), a $50.3 million, five-year investment to help the agricultural sector adapt and remain competitive.

ORGANIC FARMING RESEARCH FOUNDATION

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

References

1. Lammerts van Bueren, E.T., Jones, S.S., Tamm L., Murphy, K.M., Myers, J.R., Leifert,C., & Messmer, M.M. (2011). The need to breed crop varieties suitable for organic farming, using wheat, tomato and broccoli as examples: A review. NJAS – *Wagenigen Journal of Life Science*. (58) 193 – 205.
2. Lammerts van Bueren, E.T., Struik, P. C., van Eekeren, N., & Nuijten, E. (2018). Towards resilience through systems-based plant breeding. A review. *Agronomy for Sustainable Development*. (38) 1-21.
3. Entz, M.H., Kirk, A.P., Carkner, M., Vaisman, I., & Fox, S.L. (2018). Evaluation of lines from a farmer participatory organic wheat breeding program. *Crop Science.* (58) 2433-2443.
4. Findlater, K.M. Satterfield, T., & Kandlikar, M. (2019). Farmers' risk-based decision making under pervasive uncertainty: cognitive thresholds and hazy hedging. *Risk Analysis*. (39) 1755-1770.
5. Kloppenburg, J.R. (1991). Social theory and the de/reconstruction of agricultural science: local knowledge for an alternative agriculture. *Rural Sociology*. (56) 519-548.
6. Adam, Katherine L. 2005. "Seed Production and Variety Development for Organic Systems." IP272. Butte, MT: National Center for Appropriate Technology.
7. Murphy, K., Lammer, D., Lyon, S., Carter, B, & Jones, S. S. (2005) Breeding for organic and low-input farming systems: an evolutionary–participatory breeding method for inbred cereal grains. Renewable *Agriculture & Food Systems*. (20) 48-55.
8. Almekinders, C. J. M., Thiele, G., & Danial, D. L. (2006). Can cultivars from participatory plant breeding improve seed provision to small-scale farmers? *Euphytica*. (153) 363-372.
9. Dawson, J.C., Murphy, K.M., Huggins, D.R., & Jones, S.S. (2011). Comparison of winter wheat genotypes selected under different nitrogen regimes for traits related to nitrogen use in an organic system. *Organic Agriculture*. (1) 65-80.
10. Shelton, A.C. & Tracy, W.F. (2016). Participatory plant breeding and organic agriculture: A synergistic model for organic variety development in the United States. *Elementa: Science of the Anthropocene*. (4) p.000143.
11. Galiè, A. (2013). Empowering women farmers: The case of participatory plant breeding in ten Syrian households. *Frontiers: A Journal of Women Studies*. (34) 58-92.
12. van Frank, G., Rivière, P., Pin, S., Baltassat, R., Berthellot, J.F., Caizergues, F., Dalmasso, C., Gascuel, J.S., Hyacinthe, A., Mercier, F. and Montaz, H. (2020). Genetic diversity and stability of performance of wheat population varieties developed by participatory breeding. *Sustainability*. (12), 384.

13. Mendes-Moreira, P., Satovic, Z., Mendes-Moreira, J., Santos, J.P., Nina Santos, J.P., Pêgo, S., and Vaz Patto, M.C. (2017). Maize participatory breeding in Portugal: comparison of farmer's and breeder's on-farm selection. *Plant Breeding*. (136) 861–871.

14. Kliem, L. & Sievers-Glotzbach, S. (2022). Seeds of resilience: The contribution of commons-based plant breeding and seed production to the social-ecological resilience of the agricultural sector. International *Journal of Agricultural Sustainability*. (20) 595-614.