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REVIEW

Participatory plant breeding: Who did it, who does it and where?

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Abstract

The paper provides an overview of institutions, scientists, and practitioners involved over the years in the various ways in which participatory plant breeding (PPB) is implemented, with indication of the crops involved and the countries in which it took place, or is still taking place. This might help creating a better awareness of the scope (both geographical and crop wise) of the different methodologies as well as of their advantages, disadvantages, applicability, and limitations. Through a literature survey, we found 254 publications showing that over a period of 36 years participatory approaches in plant breeding have been used in 69 countries (10 developed and 59 developing) with 47 crops including self-pollinated, cross-pollinated, and vegetatively propagated crops, by several Institutions including CGIAR centers, universities, and NGOs. We argue that there are no obvious scientific or technical reasons limiting the use of PPB, and we interpret the limited institutionalization as a difficulty to accept the paradigm shift that participation implies.

Keywords: Participation; Participatory variety selection; participatory plant breeding

Introduction

Participatory research, in a form, which has become known as the 'Farmers First' concept, has been first proposed in two classic papers at the beginning and in the mid-1980s (Rhoades and Booth 1982; Rhoades *et al*., 1986).

Ashby and Sperling (1995) covered extensively the origin and the diffusion of the concept of involving users and clients in research and development as a principle of successful innovation. Within plant breeding, participatory research has had a very uneven growth in the scientific community, and even within CGIAR, from where it originated, only few breeders, defined as the scientists responsible for the breeding program(s) of the Center, used it despite its greater demonstrated efficiency (Ceccarelli, 2015).

Participatory research has been implemented in plant breeding as participatory plant breeding (PPB) that we define as the participation of clients (more often, but not only, farmers) in all the most important decisions during all the stages of a plant breeding program as shown in Figure 1. Depending on when the participation starts, a distinction is made between PPB and participatory variety selection (PVS). The latter is when farmers' participation begins during the testing of experimental varieties (Weltzien *et al*., 2003). While, on one side, PVS is technically easier than PPB to organize, because farmers are only involved in expressing their opinion on the limited number of lines that usually reach that stage, on the other side it leaves to them a limited number of choices to make. Furthermore, with PVS there is a risk for breeding material potentially desirable to farmers to be discarded before it is even seen by them.

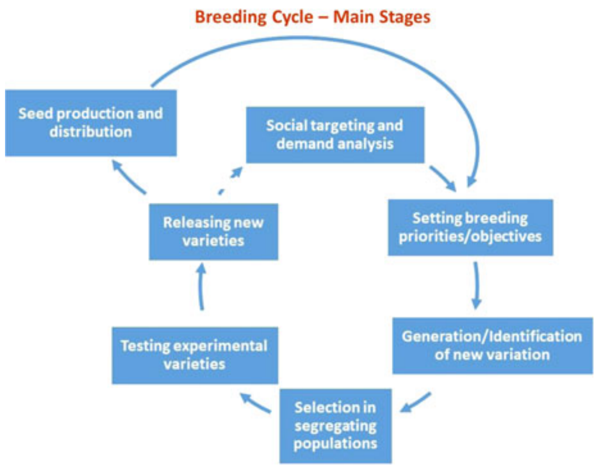

Figure 1. Main stages of a breeding program.

However, because it is simpler to organize, PVS can be a useful entry point to start experimenting with the participation of farmers, assuming that PVS is fully decentralized, namely assuming that selection is done in the target environment.

PPB is a socially inclusive process, which brings with it farmer empowerment and increased agrobiodiversity, and can improve gender equitability (Tufan *et al.*, 2018). Additional advantages of PPB/PVS are the production of varieties more resilient, with higher yield (Ceccarelli *et al.*, 2003; Gibson *et al.*, 2011), greater adoption rate (Galluzzi *et al.*, 2014), increase genetic diversity (Joshi *et al.*, 1997), and household food security (Joshi *et al.*, 2012).

PPB has been very attractive to social scientists who have been actually the first practitioners. This has, on one side, created a gap between social scientists and breeders (Ceccarelli and Grando, 2019), and on the other, has generated the belief that PPB is a methodology better suited to the developing world where many poor farmers in marginal areas have not benefitted of the conventional (non-participatory) approach (Bellon, 2006). Because of the gap mentioned above, a number of scientists, not only breeders, have used participatory approaches in plant improvement projects using various methodologies in several countries and in several crops. As a result, the literature on PPB (inclusive of PVS) is extremely varied, ranging from technical papers on the actual implementation of a PPB program, describing breeding methods, experimental designs, statistical analysis, and results, to more socially oriented papers with emphasis on the participants, to exclusively methodological and conceptual papers.

A number of reviews reported several cases of PPB/PVS. A first (to our knowledge) systematic review of PPB/PVS was done in 2003 (Weltzien *et al.*, 2003) reporting 48 cases of which 11 presented in detail. A second one was presented in the form of a paper in 2004 (Ashby and Lilja, 2004) and mentioned, without listing them, more than 200 projects using participatory approaches in 15 countries. More recently, an inventory of cases of participatory research was done as part of the SOLIBAM project (http://www.solibam.eu/) and covered 22 cases in 17 countries (Ceccarelli *et al.*, 2013).

In this paper we have updated the information on participatory research in plant breeding worldwide, including all the cases described in previous inventories. The aim is to provide as much quantitative information as possible on the extent of participatory research applied to plant breeding, which is still the subject of considerable scientific debate. In the paper we also presented some analyses of the information provided in the Supplementary appendixes (available online at http://doi.org/10.1017/S0014479719000127) as non-exhaustive examples of how that information can be used.

Methodology

We conducted a literature search using the following search engines: https://scholar.google.com/, www.getcited.org, and http://academic.research.microsoft.com. The strings used included 'participatory,' 'participation,' 'participatory research,' 'farmers' preferences,' 'plant breeding,' 'evolutionary plant breeding,' and their combinations. We searched English, Spanish, and French sources. As sources, we used referee journals, conference proceeding, book chapters, working documents, and informal reports for which printed and accessible documents were available. In all cases, we also used the reference lists as additional sources. We also shared a preliminary list of publications with 31 scientists known to be active in either PPB or PVS, and 15 of them responded with additional references. The search ended on May 31, 2018.

For the reasons discussed earlier, we included publications on both PPB and PVS, as well as more recent examples of evolutionary-participatory plant breeding (EPPB) because we consider it as a development that amplifies the benefits of PPB. Evolutionary plant breeding (EPB) was first proposed by Suneson (1956), although actually started much earlier (Harlan and Martini, 1929); it is based on letting early segregating populations evolve under the effects of natural selection. EPB becomes participatory when an evolutionary population is used by both breeders and farmers together as a source for artificial selection (Murphy *et al.*, 2005).

We classified the publications in two broad categories: those reflecting mostly experimental work (Supplementary Appendix 1) and those predominantly addressing methodological, organizational, institutional, policy, or conceptual aspects of participatory research (Supplementary Appendix II). In some cases, the distinction is not well defined. In selecting the publications to include in the inventory, our priority was to be as inclusive as possible in terms of crops, countries, objectives, and institutions. In doing so, in some cases we have not included a few publications that we felt did not add to those four criteria over and beyond those already included for the same author(s), country(ies), crop(s), and institution (s).

We included publications on adoption related to PPB and/or PVS. Bench mark adoption rates were extracted from publications on broader adoption. Papers on seed systems were also included as participatory programs considerably affect the dynamics of seed diffusion.

The trend of publications over time was graphically represented using 3 years moving means, that is, the means of subsets of 3 years in which each subset is shifted forward by 1 year at the time. For example, if the first is the mean number of publications in 1982, 1983, and 1984, the second will be the mean number of publications in 1983, 1984, and 1985, the third will be the mean number of publications in 1984, 1985, and 1986, and so on.

Although our vision of participatory research is that of a highly gender-inclusive process, we are aware that a number of social scientists prefer keeping the gender dimension separate. Therefore, we also included in the survey gender-related publications when related to plant breeding.

Eventually, when not otherwise specified, we assumed that 'wheat' was bread wheat; we kept corn separate from sweet corn and the various millets distinct from each other, when species and genus were specified. In one case when only the term 'millet' was used, we assumed it was pearl millet. We also kept papers dealing with broccoli, cauliflower, and kale as separate cases, and we did the same with papers dealing with squash (= zucchini), winter squash, and butternut squash.

Results

At the moment of writing, we have identified a total of 254 publications (including one manuscript) dealing with participatory research in plant breeding. Of these, 172 publications (Supplementary Appendix I) deal mostly with experimental work (as defined earlier), and 82

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Table 1. Crops used in PPB or PVS programs and projects, classified according to the number of times they were cited in the 172 publications (Supplementary Appendix I)

Crop	Number*	Crop	Number*
Rice	38	Oat	2
Maize	35	Squash	2
Bean	25	Teff	2
Sorghum	22	Amaranth	1
Barley	21	Buckwheat	1
Potato	17	Butternut squash	1
Bread wheat	16	Canihua	1
Pearl millet	10	Cauliflower	1
Cassava	7	Coffee	1
Broccoli	5	Cucumber	1
Cotton	5	Field bean	1
Sweet corn	5	Fonio	1
Quinoa	4	Gourd	1
Sweet potato	4	Kale	1
Tomato	4	Lupin	1
Faba bean	3	Melons	1
Pea	3	Peanut	1
Banana	2	Pepper	1
Carrot	2	Pigeon pea	1
Chickpea	2	Pumpkin	1
Cowpea	2	Sunflower	1
Durum wheat	2	Taro	1
Finger millet	2	Winter squash	1
Lentil	2		

*The total does not add to 172 because several papers deal with more than one crop.

(Supplementary Appendix II) deal predominantly with methodological and/or conceptual aspects of participatory research in plant breeding,

The first group of publications covers 47 crops (Table 1) including self-pollinated, cross-pollinated, and vegetatively propagated crops. The crops more often addressed in PPB or PVS projects or programs include some of the most important food crops such as rice, maize, bean, sorghum, barley, potato, bread wheat, and pearl millet. Interestingly, self-pollinated, cross-pollinated, and vegetatively propagated crops are included among the most frequently used crops, showing that it is not necessarily true that PPB or PVS is easier to implement with self-pollinated crops, as commonly believed.

Countries where most work on either PPB or PVS was (or is being) done are India, Ethiopia, USA, Nepal, Nicaragua, Mali, Syria, and Burkina Faso (Table 2). On one hand, this reflects the work done by few institutions, such as the International Center for Agricultural Research in Dry Areas (ICARDA) in Syria (on barley), the International Crop Research Institute for Semi-Arid Tropics (ICRISAT) in West Africa (on sorghum and pearl millet), and the CAZS Natural Resources (University of Wales, Bangor) in India and Nepal with rice. Therefore, these data fit well with the crops' data given in Table 1. USA is an interesting case, where the majority of PPB and PVS work is done on horticultural crops and some on wheat and oats mostly addressing organic agriculture (Zystro *et al.*, 2019). This proves that, contrary to a common belief, PPB and PVS are methodologies not necessarily restricted to developing countries as shown also by an additional 24 publications from other 8 developed countries addressing organic agriculture and/or local adaptation.

Since the idea of participatory research originated from within the CGIAR, one might wonder to what an extent the CGIAR contributed to the implementation and documentation of PPB/PVS after the original papers cited earlier.

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Table 2. Countries that hosted one or more PPB or PVS projects or programs with the number of times they were cited in the 172 publications (Supplementary Appendix I)

Country	Number	Country	Number
India	19	Iran	3
Ethiopia	15	Jordan	3
Mali	11	Philippines	3
Nepal	11	Senegal	3
Nicaragua	11	Yemen	3
USA	11	Cameroon	2
Burkina Faso	10	Germany	2
Syria	10	Guinea-Bissau	2
France	9	Italy	2
China	7	Malawi	2
Honduras	7	Morocco	2
Uganda	7	Nigeria	2
Bolivia	6	Tanzania	2
Portugal	6	The Netherlands	2
Cuba	5	Burundi	1
Ghana	5	Canada	1
Kenya	5	Chad	1
Mexico	5	Cote d'Ivoire	1
Niger	5	East Timor	1
Brazil	4	Egypt	1
Ecuador	4	Gambia	1
Laos	4	Guinea	1
Peru	4	Liberia	1
Rwanda	4	Mauritania	1
Vietnam	4	Namibia	1
Algeria	3	Samoa	1
Bangladesh	3	Sierra Leone	1
Benin	3	Spain	1
Bhutan	3	Sumatra	1
Cambodia	3	Togo	1
Colombia	3	Tunisia	1
Eritrea	3	UK	1
Indonesia	3	Zimbabwe	1

Table 3. The CGIAR contribution to participatory research in plant breeding (Supplementary Appendixes I and II combined)

Center	Number of publications
AFRICARICE*	1
BIOVERSITY INTERNATIONAL**	11
CIAT	18
CIMMYT	11
CIP	10
ICARDA	32
ICRISAT	18
IFPRI	3
IITA	4
ILRI	2
IRRI	10
PRGA/CGIAR	9
Total	129

*Includes those published as WARDA.
**Includes those published as IPGRI.

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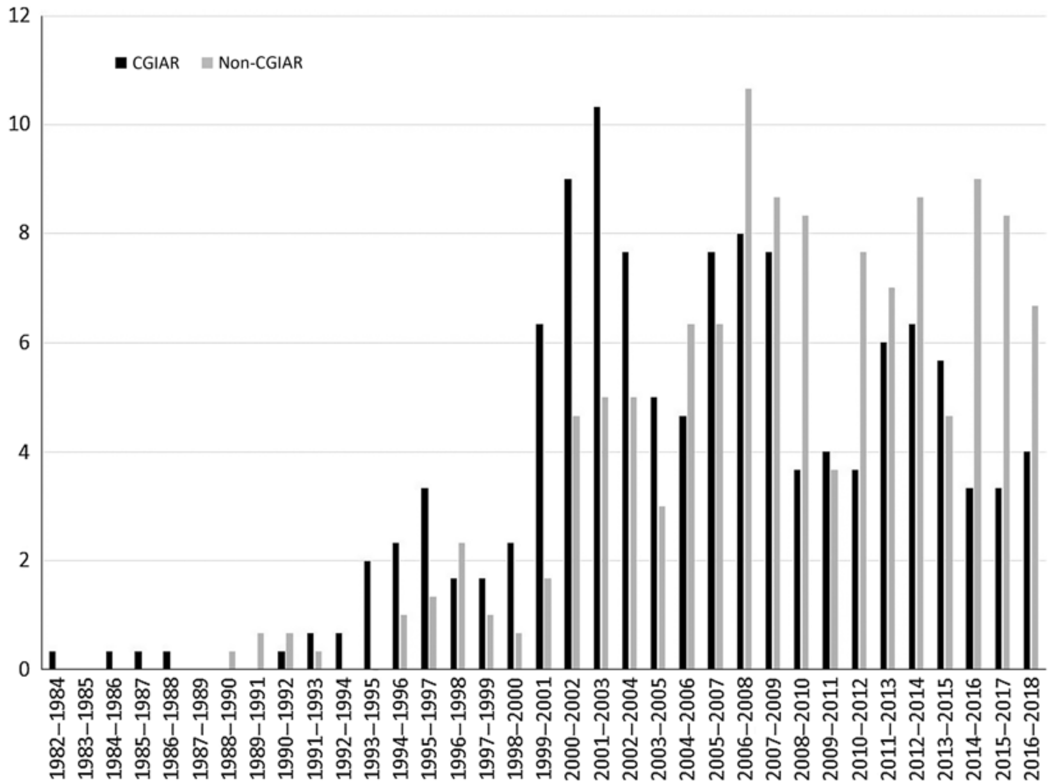

Figure 2. Contribution to publications on participatory research (those included in Supplementary Appendixes I and II) by CGIAR and non-CGIAR institutions and/or organizations during the 36 years' time frame covered by this survey (the data are 3 years moving means – see under Methodology).

Nearly all CGIAR centers (11) contributed to a different extent to PPB/PVS programs with the majority of contributions coming from ICARDA, ICRISAT, CIAT, CIMMYT, BIOVERSITY INTERNATIONAL (including those of IBPGR), CIP, and IRRI, with 10 or more publications each, followed by other 5 centers with less publications (Table 3). Eventually nine publications were attributed to the CGIAR System Wide Program for Participatory Research and Gender Analysis (PRGA), established in 1996 and closed in 2011, and, more recently, to the CGIAR Gender & Breeding Initiative (http://www.rtb.cgiar.org/gender-breeding-initiative/).

Using 3 years moving means, the temporal distribution of the CGIAR publications on PPB/PVS shows a steady increase until 2001–2003 (Figure 2), followed by a fluctuating trend with a tendency to decline. On the other hand, while the contribution of non-CGIAR institutions, with some exceptions, was lower than the contribution of CGIAR until the mid-2000, it become higher afterword. The decline of PPB/PVS programs in the CGIAR is likely to be associated with the shift toward more upstream research.

As many as 60 universities contributed publications to either PPB or PVS (Table 4), the majority of which (44 or 75% of the total) from 11 developed countries. Among those, the majority were from USA, UK, and Italy. The interest in PPB in these countries could be associated with the fact that PPB is mainly implemented in organic agriculture (Shelton and Tracy, 2016), which is rapidly expanding. In the case of USA, the interest in PPB could also be associated with a less rigid seed system as compared to Europe.

Table 4. Universities, countries, and number of publications they contributed on PPB or PVS (Supplementary Appendixes I and II combined)

University	Country	Number
University of Sidi Bel Abbes	Algeria	1
University of Queensland	Australia	2
University of Guelph	Canada	2
McGill University	Canada	1
University of Manitoba	Canada	1
Zhejiang University	China	1
University of Zagreb	Croatia	2
Mekelle University	Ethiopia	4
Alemaya University	Ethiopia	3
University of Paris 3 SorbonneSud	France	1
University of Paris Sud	France	1
Georg August University	Germany	2
University of Hohenheim	Germany	2
Humboldt Univ. Berlin	Germany	1
University of Kassel	Germany	1
Escuela Agricola Panamericana Zamorano	Honduras	2
Banaras University	India	1
Gujarat University	India	1
Indira Gandhi Agricultural University	India	1
Narendra Deva University of Agriculture	India	1
Orissa University of Agriculture and Technology	India	1
Rajendra Agricultural University	India	1
University of Agricultural Sciences Dharwad	India	3
University of Bologna	Italy	1
University of Rome	Italy	1
University of Tuscia	Italy	1
University of Naples	Italy	1
Scuola Superiore Sant'Anna Pisa	Italy	2
Padova University	Italy	1
University of Jordan	Jordan	2
University of Nairobi	Kenya	1
Norwegian University of Life Sciences	Norway	4
University of Lisbon	Portugal	1
University of Porto	Portugal	1
University of Kwazulu Natal	South Africa	1
University of Basel	Switzerland	1
Wageningen University	The Netherlands	19
Bangor University	UK	14
University of East Anglia	UK	2
University of Reading	UK	2
University of Birmingham	UK	1
University of Edinburgh	UK	1
University of London	UK	1
University of Wales Swansea	UK	1
University of Wisconsin	USA	11
Cornell University	USA	9
Oregon State University	USA	9
University of California	USA	6
Washington State University	USA	5
Iowa State University	USA	3
Pennsylvania State University	USA	2
University of Arizona	USA	2
Yale University	USA	2
Kansas State University	USA	1
Laurentian University	USA	1
Mercer University	USA	1
Michigan State University	USA	1
North Dakota State University	USA	1
Purdue University	USA	1
University of Nebraska	USA	1

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Table 5. Institutions (other than universities and CGIAR centers), countries, and number of publications they contributed on PPB or PVS (Supplementary Appendixes I and II combined)

Institution	Country	Number
CIRAD	France	17
INRA	France	17
LI-BIRD	Nepal	7
CIPRES	Nicaragua	6
CCAP	China	5
ESAC	Portugal	5
INTA	Nicaragua	5
ITAB	Portugal	5
Organic Seed Alliance	USA	5
EIAR	Ethiopia	4
FIBL	Switzerland/Germany	4
INCA	Cuba	4
ACCI	South Africa	3
bioRe	India	3
EAN	Portugal	3
FIPAH	Honduras	3
IDRC	Canada	3
INERA	Burkina Faso	3
INGER	Cambodia	3
NRI	Uganda	3
AIAB	Italy	2
Chetna Organic	India	2
CREA	Italy	2
CRRI	India	2
CRURRS	India	2
EMBRAPA	Brazil	2
Gramin Vikas	India	2
GVT	Bangladesh	2
IER	Mali	2
INIFAP	Mexico	2
INRAB	Benin	2
IRD	Mexico	2
ISD	USA	2
KARI Kenya	Kenya	2
KARI Uganda	Uganda	2
KRIBP	India	2
NAFRI	India	2
NAFRS	Laos	2
NARC	Nepal	2
PROIMPA	Bolivia	2
RSR	Italy	2
UACT	Mali	2

Only institutions that contributed two or more publications are reported.

There is no relationship between the data of Table 4 and those of Table 2, because Table 4 shows only the affiliation of the author(s) who actually did their work in a different country(ies).

A total of other 140 research institutions, NGOs and other associations contributed significantly to PPB or PVS with a number of publications during the 36 years period covered by this survey, ranging from 1 to 17: those with 2 or more publications are shown in Table 5.

Although the papers listed in Supplementary Appendixes I and II come from a wide range of publications, 160 (63.2%) were found in referee journals. Of these, 112 (44% of the 254 papers) were found in 14 referee journals (Table 6) with only two journals accounting for 67 papers, that is, slightly more than a quarter of all the publications.

Table 6. Referee Journal that published the majority of papers (Supplementary Appendixes I and II combined)

Journal	Number	%
Euphytica	39	15.35
Experimental Agriculture	28	11.02
Agronomia Mesoamericana	8	3.15
Field Crops Research	7	2.76
Plant Breeding	5	1.97
African Journal of Agricultural Research	4	1.57
Renewable Agriculture and Food Systems	4	1.57
Journal of Crop Improvement	3	1.18
NJAS – Wageningen Journal of Life Sciences	3	1.18
Journal of Agricultural Science	3	1.18
Genetic Resources and Crop Evolution	2	0.79
Journal of Rural Studies 36: 182–196	2	0.79
Science	2	0.79
Sustainability	2	0.79
Total	112	44.09

Discussion and Conclusions

One of the most interesting results of this survey is that there is no correspondence between the frequencies with which PPB and/or PVS has been practiced and its institutionalization as the example of Ethiopia and India, but also Syria, Burkina Faso, and Mali shows. In all these countries, despite the evidence of its benefits, institutional (public) plant breeding is still centralized and non-participatory. In these countries, one of the reasons for the lack of adoption of PPB is the reward system for public breeders, which is still largely based on the variety release. Involving other partners in the selection process implies sharing the merit of obtaining a new variety. In many countries, one of the reasons often quoted is the seed legislation as an obstacle to PPB variety registration and release although there are examples – not many – of varieties released from PPB such as potato (Laurie and Magoro, 2008), rice (Gyawali *et al.*, 2010), and sweet potatoes (Gibson *et al.*, 2011).

The involvement of several universities, including many from developed countries and of other research organizations (such as CIRAD, INRA, LI-BIRD, and CIPRES among others), is a strong indication that PPB and PVS have solid scientific basis, although even in these countries, most of the public plant breeding is non-participatory.

PPB has been often considered to be more expensive than conventional plant breeding, and in fact, a cost analysis of PPB shows that its costs are higher than conventional plant breeding, particularly because of the incidence of the travel component (Mangione *et al.*, 2006). However, we have argued (Ceccarelli, 2015) together with others (Walker, 2006; Witcombe and Yadavendra, 2014) that what needs to be considered is the benefit/cost ratio which is considerably higher in PPB due to the higher rate of variety adoption (Witcombe and Yadavendra, 2014). One of the main obstacles to a wider adoption of PPB could be the difficulty to perceive those advantages but also the breeding curricula in several universities, which is almost entirely based on formal plant breeding. Another likely obstacle to a wider adoption of PPB has to be found in the reluctance to accept the paradigm shift that PPB inevitably implies in what might be called 'seed sovereignty' and, consequently, 'food sovereignty.' In fact, PPB is a reversal of the model defined 'delegative' (from the French *délégatif*) by Bonneuil and Demeulenaere (2007) and by Thomas et al. (2011). In that model, agricultural production, seed production, varietal innovation, and conservation of genetic resources are functionally separated and delegated to specialized scientists. Farmers lost the responsibilities for innovation and conservation that they had for millennia in a process defined as farmers' deskilling (Fitzgerald, 1993) or 'dispossession' (Kloppenburg, 2010). The model that resulted in a system of power, authority, and control was well established at the

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time participatory research was first proposed. PPB is reversing this model and is seen as very radical and perhaps even subversive (Crane, 2014), because it may eventually lead that what Kloppenburg (2010) has defined as a 'repossession.'

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Supplementary materials. For supplementary material for this article, please visit http://doi.org/10.1017/S0014479719000127

References

Ashby J.A. and Lilja N. (2004). Participatory Research: Does It Work? Evidence from Participatory Plant Breeding, New directions for a Diverse Planet, Proceedings of the 4th International Crop Science Congress, 26 Sep–1 Oct 2004, Brisbane, Australia.

Ashby J.A. and Sperling L. (1995). Institutionalizing participatory, client-driven research and technology development in agriculture. *Development and Change* **26**, 753–770.

Bellon M.R. (2006). Crop research to benefit poor farmers in marginal areas of the developing world: a review of technical challenges and tools. *CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources* **1**, No 070, 11.

Bonneuil C. and Demeulenaere E. (2007). Une génétique de pair à pair? L'émergence de la sélection participative. In Charvolin F., Micoud A. andNyhart L.K. (eds), *Les sciences citoyennes. Vigilance collective et rapport entre profane et scientifique dans les sciences naturalists*, LaTour-D'Aigues, France: Edition de l'Aube, pp. 122–147.

Ceccarelli S. (2015). Efficiency of plant breeding. *Crop Science* **55**, 87–97.

Ceccarelli S., Al Yassin A., Goldringer I., Mendes Moreira P. and Chable V. (2013). *Analysis of Major Participatory Plant Breeding Worldwide*. Available at https://prodinra.inra.fr/ft?id=A3E52EA1-0BF8-40E7-8A78-2BBBC5FF912B. Accessed 26 November 2018

Ceccarelli S. and Grando S. (2019). From participatory to evolutionary plant breeding. In Westengen O. and Winge T. (eds), *Farmer Participation in Plant Breeding: Current Approaches and Perspectives*, Abingdon, UK: Routledge.

Ceccarelli S., Grando S., Singh M., Michael M., Shikho A., Al Issa M., Al Saleh A., Kaleonjy G., Al Ghanem S.M., Al Hasan A.L., Dalla H., Basha S. and Basha T. (2003). A methodological study on participatory barley breeding. II. Response to selection. *Euphytica* **133**, 185–200.

Crane T.A. (2014). Bringing science and technology studies into agricultural anthropology: Technology development as cultural encounter between farmers and researchers. *Culture, Agriculture, Food and Environment* **36**, 45–55.

Fitzgerald D. (1993). Farmers deskilled: Hybrid corn and farmers' work. *Technology and Culture* **34**, 324–343.

Galluzzi G., Estrada R., Apaza V., Gamarra M., Pérez A., Gamarra G., Altamirano A., Cáceres G., Gonza V., Sevilla R., López Noriega I. and Jäger M. (2014). Participatory breeding in the Peruvian highlands: Opportunities and challenges for promoting conservation and sustainable use of underutilized crops. *Renewable Agriculture and Food Systems* **30**, 408–417.

Gibson R.W., Mpembe I. and Mwanga R.O.M. (2011). Benefits of participatory plant breeding (PPB) as exemplified by the first-ever officially released PPB-bred sweet potato cultivar. *The Journal of Agricultural Science* **149**, 625–632.

Gyawali S., Sthapit B.R., Bhandari B., Bajracharya J., Shrestha P.K., Upadhyay M.P. and Jarvis D.J. (2010). Participatory crop improvement and formal release of Jethobudho rice landrace in Nepal. *Euphytica* **176**, 59–78.

Harlan H.V. and Martini M.L. (1929). A composite hybrid mixture. *Journal of American Society of Agronomy* **21**, 487–490.

Joshi K.D., Devkota K.P., Harris D., Khanal N.P., Paudyal B., Sapkota A. and Witcombe J.R. (2012). Participatory research approaches rapidly improve household food security in Nepal and identify policy changes required for institutionalization. *Field Crops Research* **131**, 40–48.

Joshi K.D., Subedi M., Rana R.B., Kadayat K.B. and Sthapit B.R. (1997). Enhancing on-farm varietal diversity through participatory varietal selection: A case study for chaite rice in Nepal. *Experimental Agriculture* **33**, 335–344.

Kloppenburg J. (2010). Impeding dispossession, enabling repossession: biological open source and the recovery of seed sovereignty. *Journal of Agrarian Change* **10**, 367–388.

Laurie S.M. and Magoro M.D. (2008). Evaluation and release of new sweet potato varieties through farmer participatory selection. *African Journal of Agricultural Research* **3**, 672–676.

Mangione D., Senni S., Puccioni M., Grando S. and Ceccarelli S. (2006). The cost of participatory barley breeding. *Euphytica* **150**, 289–306.

Murphy K., Lammer D., Lyon S., Carter B. and Jones S.S. (2005). Breeding for organic and low-input farming systems: An evolutionary-participatory breeding method for inbred cereal grains. *Renewable Agriculture and Food Systems* **20**, 48–55.

Rhoades R.E. and Booth R.H. (1982). Farmer-back-to-farmer: a model for generating acceptable agricultural technology. *Agricultural Administration* **11**, 127–137.

Rhoades R.E., Horton D.E. and Booth R.H. (1986). Anthropologist, biological scientist and economist: The three musketeers or three stooges of farming systems research? In Jones J.R. and Wallace B.J. (eds), *Social Sciences and Farming System Research. Methodological Perspectives on Agricultural Development*, Boulder: Westview Press, pp. 21–40.

Shelton A.C. and Tracy W.F. (2016). Participatory plant breeding and organic agriculture: A synergistic model for organic variety development in the United States. *Elementa Science in the Anthropocene* **4**, 143.

Suneson C.A. (1956). An evolutionary plant breeding method. *Agronomy Journal* **48**, 188–191.

Thomas M., Dawson J.C., Goldringer I. and Bonneuil C. (2011). Seed exchanges, a key to analyze crop diversity dynamics in farmer-led on-farm conservation. *Genet Resources Crop Evolution* **58**, 321–338.

Tufan H.A., Grando S. and Meola C. (eds) (2018). *State of the Knowledge for Gender in Breeding: Case Studies for Practitioners*. Lima (Peru): CGIAR Gender and Breeding Initiative. Working Paper. No. 3. Available at www.rtb.cgiar.org/gender-breeding-initiative Accessed 26 November 2018

Walker T.S. (2006). Participatory varietal selection, participatory plant breeding, and varietal change. *Background paper for the World Development Report 2008*. Washington, DC: World Bank.© World Bank, License: CC BY 3.0 IGO Available at https://openknowledge.worldbank.org/handle/10986/9182. Accessed 26 November 2018

Weltzien R.E., Smith M.E., Meitzner L.S. and Sperling L. (2003). Technical and institutional issues in participatory plant breeding-from the perspective of formal plant breeding: A global analysis of issues, results, and current experience. In PRGA Program Coordination Office (ed), *CGIAR System wide Program on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation*. PPB Monograph no. 1. Cali, CO: Centro Internacional de Agricultura Tropical (CIAT), 208 pp. ().

Witcombe J.R. and Yadavendra J.P. (2014). How much evidence is needed before client-oriented breeding (COB) is institutionalized? Evidence from rice and maize in India. *Field Crops Research* **167**, 143–152.

Zystro J., Colley M. and Dawson J.C. (2019). Alternative experimental designs for plant breeding. *Plant Breeding Reviews* **42**, 87–117.

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