FiBL
EXCELLENCE FOR SUSTAINABILITY

Research Institute of Organic Agriculture
Forschungsinstitut für biologischen Landbau
Institut de recherche de l'agriculture biologique

Challenges of Participatory Plant Breeding

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Outline

- FiBL Plant breeding strategies
- Why participatory plant breeding ?
  - Level of participation
  - Principles of participatory research
- Challenges of participatory plant breeding
  - Who to get started
  - Communication / Common language
  - Definition of common goals
  - Long term engagement & Gender aspect
  - Implementation of PPB & Struggle with on farm trials
  - Data assessment & sample handling
  - Legal aspects and financing
- Impact of participative plant breeding

FiBL Plant Breeding Strategy

- **Focus on traits that have not been addressed in plant breeding so far**
  - Improved nutrient use efficiency and plant health by breeding for improved Plant – Microbe Symbioses
  - Breeding for mixed cropping (Plant – Plant Interaction)
  - Utilizing Genotype x Management Interaction (low input, organic)
  - Seed born diseases
- **Focus on crops where availability or choice of cultivars is limited**
  - Cash crops where hybrid seeds are too expensive
  - Neglected local crops and legumes (biological N fixation)
  - According to demand of smallholders

FiBL Plant Breeding Strategy

- **Networking & Transdisciplinary Research to start and enforce local seed and breeding activities**
  - Involvement of all stakeholders and politcal lobbying
  - Capacity building of smallholders to improve their seed supply
  - Training in seed multiplication, seed processing, seed testing and storage
  - Development of local seed chain and cultivar testing
  - Establishment of decentralized participatory breeding activities with smallholders (including farmers, breeders, researchers, processors and retailers)

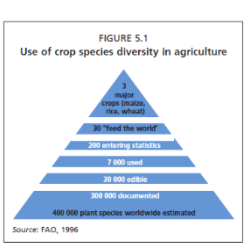
→**seed sovereignty, local seed production, diversity**

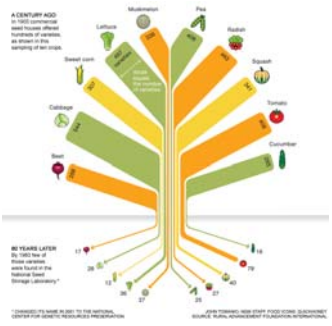
FiBL Plant Breeding Strategy

- **Science based breeding research**
  - Advice in new breeding techniques
  - Combine participatory breeding with marker assisted selection
  - Develop efficient screening methods for plant breeding for improved symbiosis
- **Fast implementation of new cultivars**
  - Independent cultivar testing under organic and low input growing conditions under farmers' condition (on farm testing)
  - Development of marketing strategies for improved cultivars
  - Cultivar recommendations combined with management guideline

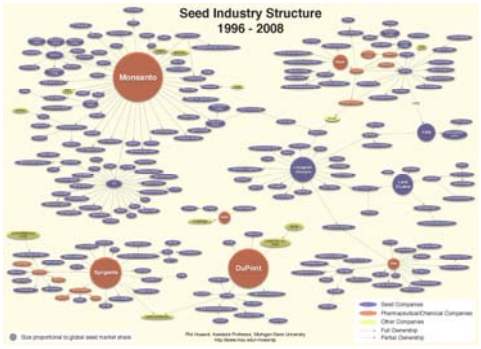
Why we need Participatory Plant Breeding?

Reduced number of crops & varieties per crop



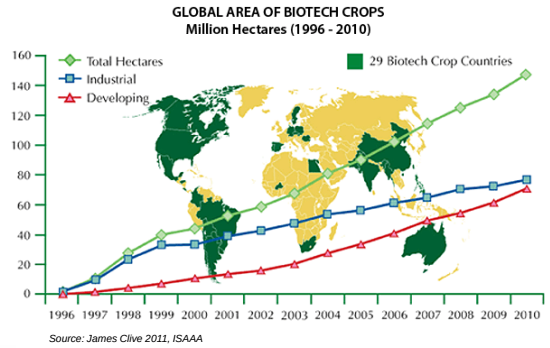


Concentration on global seed market



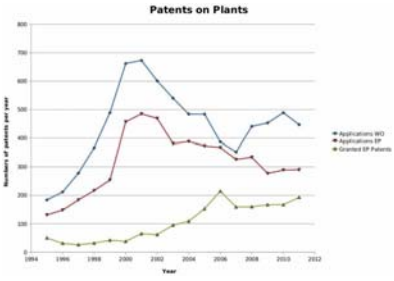
Howard, 2009, Visualizing Consolidation in the Global Seed Industry: 1996–2008 Sustainability

Increase of GM varieties



Source: James Clive 2011, ISAAA

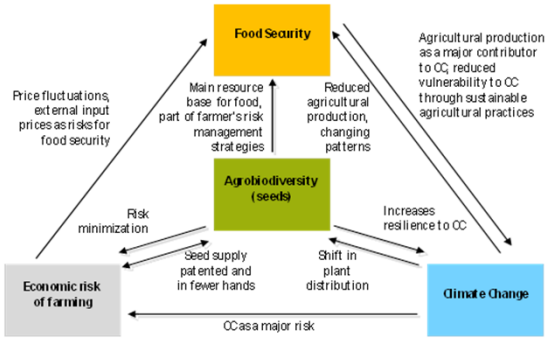
Why we need Participatory Plant Breeding?



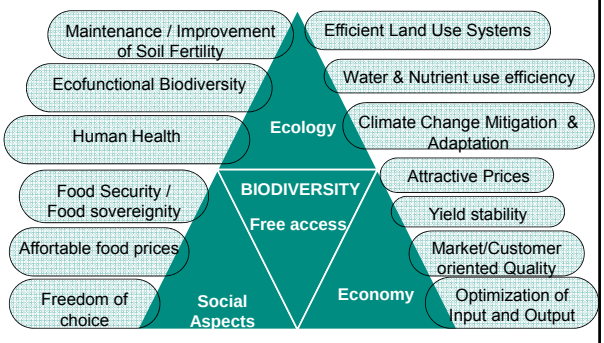
Overview of patent applications on plants under PCT/WIPO (WO) and at the EPO as well as of patents granted by the EPO. Research according to official classifications (IPC A01H or C12N001582). Christoph Then & Ruth Tippe March 2012 www.no-patents-on-seeds.org

Who will control the *Green Economy?* www.etcgroup.org

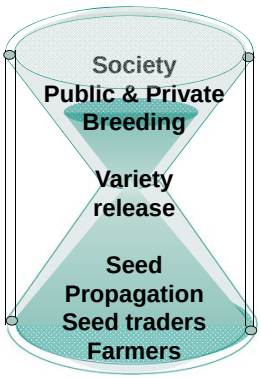
Food Security & Plant Breeding



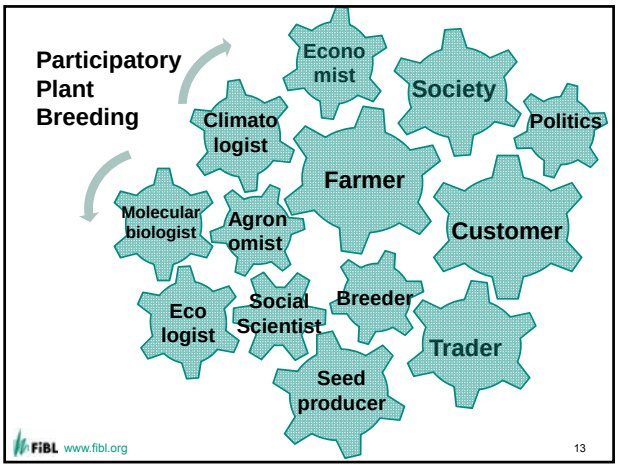
Sustainable Use of Plant Genetic Resources



Formal Plant Breeding

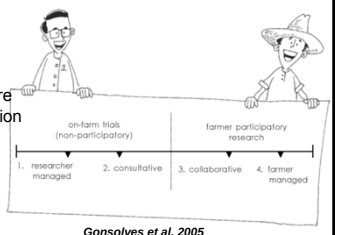


One Way Information:
Scientist
↓
Extension Service
↓
Farmer



Level of participatory research

- **Conventional**
  Research managed on station or on farm trials
- **Consultative**
  Information sharing, farmers are consulted scientists take decision
- **Collaborative**
  Task sharing between farmers and scientists
- **Farmer managed**
  no scientists involved



Gonsolves et al. 2005

→Collegial: collective decision in group process, sharing responsibility and accountability

Participative breeding of locally adapted Durum wheat

coordinated by Dominique Desclaux INRA Montpellier

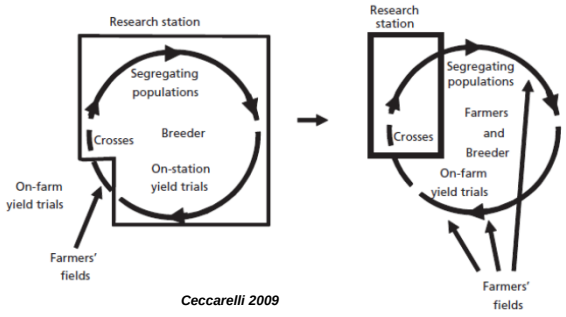
Goal: locally adapted varieties for local products, supporting diversity, strengthening of rural regions

- Comprehension of **farmers, breeders, merchant, consumer, sociologists** (supports exchange of industry & farmers, consciousness of consumers) → leading to new breeding criteria
- Respecting local conditions (soil, climate, management) → decentralized test ***on farm***
- Farmers are involved in decision processes (not only end user of varieties but included in development stage)
- Marketing aspects are included from the start

→ **collegial process**

www.selection.participative.cirad.fr

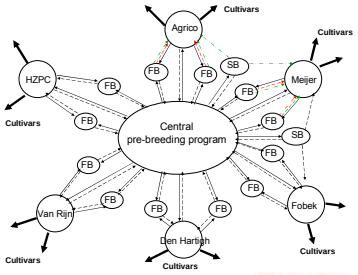
Different Timing of Participation in the Breeding Process



Ceccarelli 2009

Participatory Potato Breeding in the Netherlands for Phytothora resistance

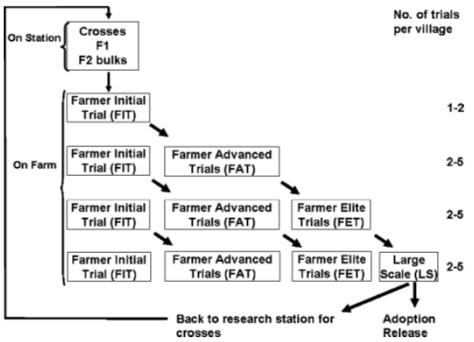
Exploiting different forms of PPB, e.g. in potato in NL (2008-2013):



Edith Lammerts van Büren 2009

Participatory breeding in self-pollinated crops

Ceccarelli, ICARDA



Quelle: Ceccarelli et al. 2007: Participatory plant breeding in water limited environments

Evolutionary plant breeding
Genetically heterogenic varieties

Composite cross (Wolfe, Elm Farm, UK)

- **Instead of breeding homogeneous varieties, as many elite varieties as possible are crossed and planted at different sites and multiplied under natural selection pressure**

→ ideal adaptation of varieties to local site demands

→ varieties can handle stress more easily because of high heterogeneity

→ reduced risk of breakdown of monogenic inherited resistances

Example: Composite crosses of winter wheat

Phillips and Wolfe 2006 Evolutionary plant breeding for low input systems

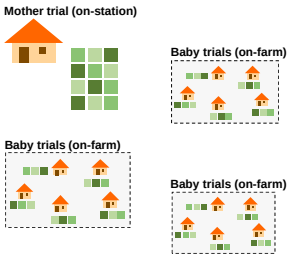
Participatory approaches in broccoli – USA for open-pollinated varieties

- Started from an initial broad base population;
- 500 - 1000 seeds sent to each grower to plant, select, allow random mating and harvest seed;
- Portion of harvested seed returned to breeder;
- Seed mixed and redistributed for 3 cycles;
- Cultivar development.

J. Myers, Oregon State University

Methodologies and Tools for Participatory Research

- **Participatory rapid appraisal**
- **Mother Baby Trial**
- **Farmer field schools**
- **Farmer research committees**
- **Participatory technology development**
- **Action research**

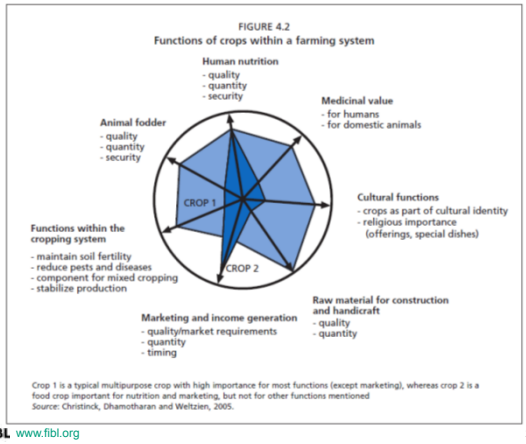


Participatory Action Research

- **Method used to involve community residents, clients, and other constituents in social change oriented research**
- **Participants work with a facilitator to identify a community problem, develop research methodology, collect data, and analyze findings**
- **The data is then used to make recommendations about how the problem should be resolved**
- **Participants advocate for funding, legislation, or government action to adopt the findings**
- **The end result is to alleviate oppression or improve community or service quality**

How to get started with PPB

- **Choice of crop**
- **Indentify relevant stakeholders**
- **Identify most urgent needs, market opportunities**
  - Public driven breeding initiative
  - Market driven breeding initiative
  - Farmer driven breeding initiative
- **Define common breeding goals**
- **Find context related solutions**
- **Organize collaborative process**
- **Identify persons with high engagement**
- **Organize neccessary infrastructure**
  - On farm trials, Seed supply, logists
  - Communication plateform



Definition of common goals

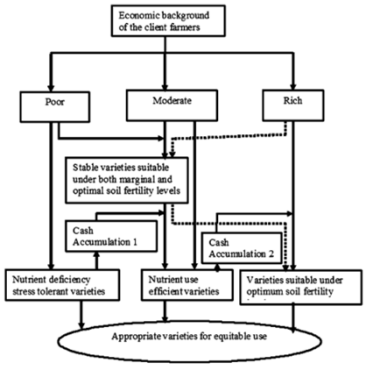
- **Find common solution for conflicting interest of different stakeholders**
  - Trades more interested in quality
  - Farmers more interested in agronomic performance
  - Breeders are interested to be competitive to seed company (unique characteristics)
  - Multilipliers more interested easyness of seed multiplicaiton
  - Researchers more interested in publications
  - Customers interested in diversified products
  - Politicians most interested in food and income security
  - Environmentalists most interested in climate change mitigation and sustainable environmentally friendly production…

Example of workshop of small scale producers and processors of Cassava from Brazil

- **Most important recommendations**
  - **Identify most urgent problems** (drought, planting material, credit, markets)
  - **Prioritize technologies and knowledge for short term and midterm goals**
- **Collaboration between biotechnologist, applied research, and farmers (from the gene to the market)**
- **Work on local level**
  - **Sensitize farmers, technicians, cassava stakeholders**
  - **Identify specific local problems** (e.g. root rot in the Northeast)
  - **Use locally available material**
- **Training in relevant technologies**

Thro and Spillane, 2000

Demand driven breeding of food legumes

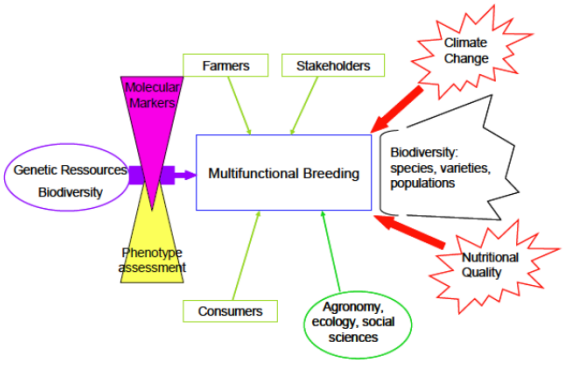


Keneni and Imtiaz, 2010

Pool relevant knowledge

- **Traditional & local knowledge of farmers**
  - On cultivation & utilization practice, seed multiplication & farmer's selection often very difficult to get access
- **Breeder's knowledge**
  - Crossing techniques, heritability of traits, relatedness of different traits, selection methods, artificial inoculation
- **Processors/Trader's Knowledge**
  - Technological quality, customers preferences, quality requirements
- **Researchers' Knowledge**
  - Genetic basis of traits, genetic diversity of accessions, access to genetic material, physiological important traits
- **Socio-economic Knowledge**
  - on market potential

Plant Breeding



COST Project SUSVAR 2008

Find common language

- **Different native languages**
- **Scientific language of different disciplines**
- **Intuition & traditional knowledge of farmers**
- **Emotional attachment of farmers**
  - **Careful wording („genetic resources" offending living organisms)**
- **Find settings to get in close and trustful dialog**
- **Respecting different way of thinking and needs**
- **Involve sociologist to facilitate better understanding**
- **Define common vision to enforce strong committment**

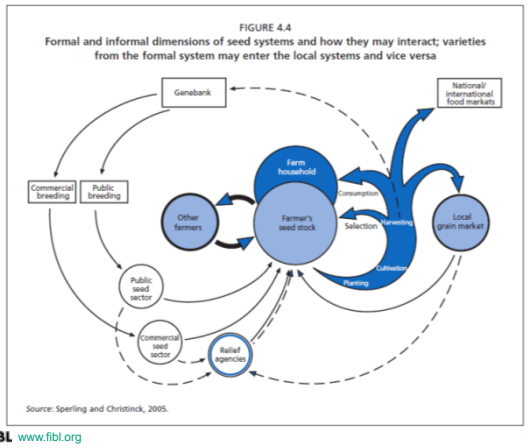
Change of interaction

- **Close multidisciplinary & transdisciplinary collaboration**
- **Evolution from research driven to farmer driven activities**
- **Sharing of knowledge and collective learning by integrating new knowledge from different disciplines**
- **Specific tools for group learning and spread of innovation**
  - Facilitated group discussions using cards, charts, voting, …
  - Field visit and demonstration trials
  - Assessment of results PPB using scoring forms based on agreed criteria
  - Interpretation of results & futher improvements

Sourcing of Seeds

- **Farm saved seeds (e.g., landraces)**
- **Commercially available seeds if not**
  - **protected by IP rights (Patent)**
  - **Restricted by breeder's exemptions** (needs registration as breeder)
- **International and national gene banks, research intistutions**
  - Small quantity of seeds
  - Genetic resources are of national ownership, MTA and ABS→ complex negotiations
- **Exchange with commercial and public breeders**
  - Often restricted due to conflict of interest (competition)
- **Local and international seed net works, NGO** → open seed source

 Quaranteen regulations !!!



Implementation of PPB

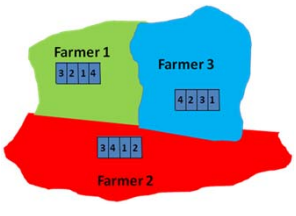
- **Incorporate research needs of local communities into design**
- **Start with few on farm trials**
- **Chose appropriate on-farm design and do NOT duplicate a research trial on-farm**
- **Spread on farm trials in stepwise procedure after training and engagement of interested farmers**
- **Initiate working groups within village**
- **Exchange knowlegde between villages**
- **Regular meetings of all stakeholders**
- **Cooperation learning between researcher, breeder and farmer**
- **Communication of results among stakeholders**

Implementation of PPB

- **Adjust design to local condition, field size, number of involved farmers**
  - Choose homogeneous farmers' fields
- **Keep it simple**
  - limited number of entries, reps
- **Focus on most relevant traits & contextual data**

  (Documentation of crop management & most relevant soil and weather conditions)
- **Use different techniques to collect the same data by different participants to verify assessment**
- **Assess G x E interaction based on unreplicated farmers' fields**

Start of on farm trial and training



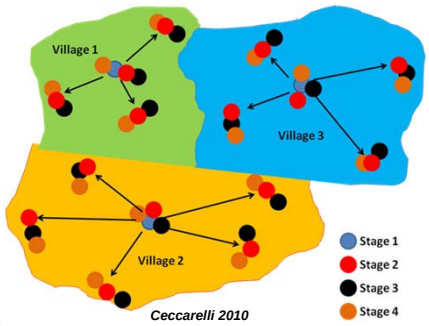
Ceccarelli 2010

Capacity building in

- Varietal Testing
- Seed multiplication
- Seed processing & cleaning
- Germination Testing
- Seed Health
- Storage
- Crossing techniques
- Selection techniques

Regular Workshops with all Stakeholders
Farmers Field days and Demo Trials

Spreading of on farm trials



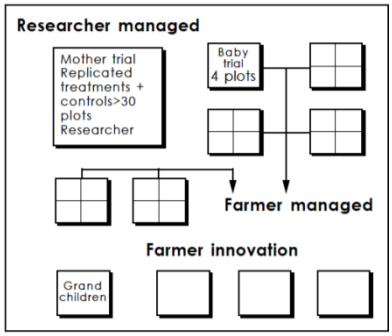
Ceccarelli 2010

PPB as evolving process

- **Challenges of on farm trials**
  - Demanding to organize decentralized field trials
  - Communication with many actors with different background
  - Unexpierienced in field trial set up, recording field data
  - Less controlled conditions
  - Less homogeneous
  - Limited availablibility (not all have e-mail, mobile phones)
  - Risk of neglecting field trial during peak times

→ develop clear field plan and field book together with farmer after definition of best field site
→ develop permanent and easy labelling system
→ agree on recording and sampling procedure
→ continuous learning and adjustments

Shift from research managed trials to farmers innovations



Snapp 2012 http://www.extension.org/organic_production

Accompanying process of PPB

- **Review knowledge obtained**
- **Agree and update on a shared agenda**
- **Adopt research questions and options to test (some may participate at different levels)**
- **Invest in partnership building, education and capacity building**
- **Facilitated discussions and brainstorm sessions**
- **Build in time for reflection**
- **Keep all participants motivated and engaged**
- **Communication and exchange is essential !!!**
- **Acknowledgement of achievements**

Long term engagement of participants

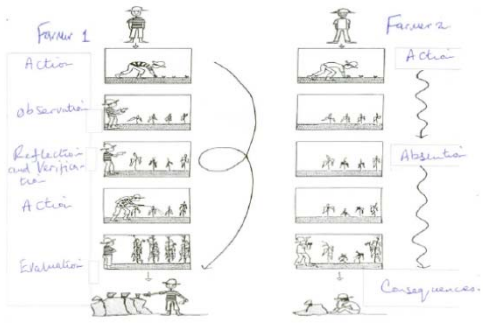


Fig. 1 Two farmers cultivating maize (German and Gohl, 1996)

Gender aspect in PPB

- **Women have often less access to land, new technologies but are heavily involved in field work, food processing, responsible for traditional knowledge and house keeping**
- **Special emphasis are needed to include women in the participative process for their empowerment**

Women

- **have different focus on crops than men → different more comprehensive criteria are considered**
- **are often better distributors of information, better team players**
- **are often more persistent to long term activities while men are more enthusiastic about short term progress**

Men and women's perceptions of most important maize variety characteristics

Characteristic		Percent of decision-makers rating characteristic as "very important" Men	Women
Agronomic			
grain weight (kg/almud)+		76.3	76.6
grain yield (kg/ha)		52.8	66.1
length of growing period		46.5	46.9
produces "something" even in bad years	*	63.8	89.8
drought tolerant		91.1	89.9
weed tolerant		26.7	39.8
disease resistant	*	31.5	61.4
resistant to insects in storage		79.7	75.5
Consumption-related			
taste of tortillas	*	50.8	78.4
good for atole	*	34	60.2
good for tamales	*	14.9	38.4
good for pozol	*	8.3	25.4
good for tlayudas		27.5	50.7
good for forage		30.9	51.4
good for feed		37.1	50
Management			
good for sale		32.4	53.6
produced with little labour		37.4	43.5
produced with few purchased inputs		48.2	57.5

* Chi-square test of homogeneity shows significant differences between men and women at the 0.1 level of significance

Source: Bellon *et al.*, Identifying maize landraces for participatory breeding: a case study from the central valleys of Oaxaca, Mexico. Unpublished manuscript. CIMMYT.

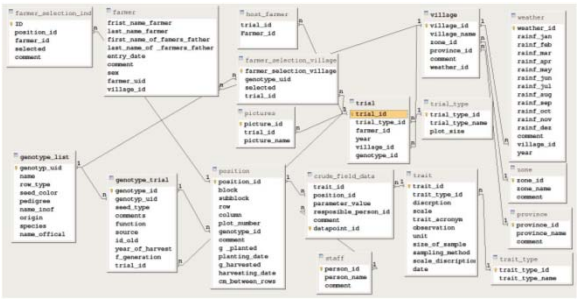
Data assessment, recording & Sample handling

- Evaluation criteria (visualized criteria book)
  - Farmers' criteria
  - Researchers' criteria
- Code for labelling of plots
  - year_site_experiment_genotype
- Evaluation sheets for
  - Farmer hosting on farm trial
  - Researcher visiting on farm trials
  - Farmer visiting on station or on farm trials
  - Facilitated group evaluation using scores, ranking, charts
- Sampling procedure for quality analysis
- Seed saving for further selection
- Over all assessment of results

Management of Data & Material

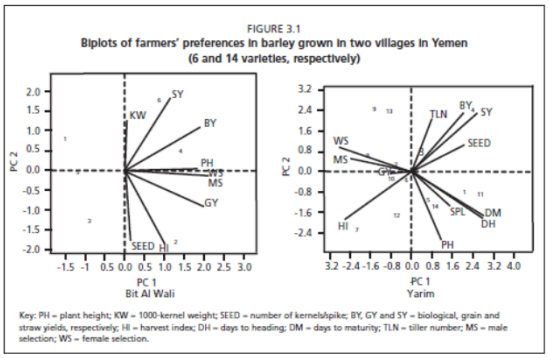
- Creation of common database (Rosenfeld MS 2011)
- Statistical analysis of recorded on station and on farm data
  - ANOVA
  - GxE biplots
- Statistical analysis of farmers' expectations and preferences
  - Multicriteria mapping
  - Grid analysis
- Results provided to participants for selection
- Central storage of seeds
- Sharing of seeds based on farmers' choice

PPB-ase: user-friendly open source database for participatory breeding programs



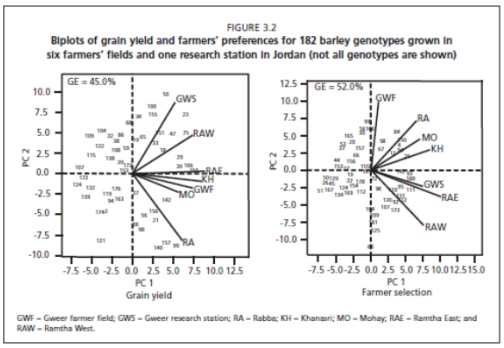
Simon Rosenfeld, MS thesis 2010 University of Hohenheim

Biplot of farmers preference in different villages



Ceccarelli 2009

Biplot of grain yield versus farmers selection



Ceccarelli 2009

Risk of participatory plant breeding

- Distrust and conflict among participants
- Length of time needed to develop consensus around goals, mission, and methods
- The need for training around research methods, data collection, and analysis
- The need for skilled facilitation, coordination, and follow-up on task completion
- Money and an organizational structure are needed to do all these things
- The group must be able to implemtent breeding activities in order to achieve an outcome

Requirements for participatory plant breeding

- Trusting relationships among members must be developed in order for a consensus about project goals, data collection methods, an analysis of findings, and recommendations can be reached.
- Training about research methods, data collection, and analysis must be provided for the participants.
- Establishing a good organizational structure to support the work team
- The provision of strong administrative support and adequate resources for the project
- A skilled facilitator to coordinate the process.

Opportunity for Change

- Accomodation
  - Making adjustment to existing system
  - Improve efficiency
  - Reorganize components, procedures, responsibilities (improve effectiveness)
- Reformation
  - Critically reflective adaptation
  - Questioning existing practice, procedures, regulations
  - Collective learning beyond present system
- Transformation
  - Creative redesign of whole system
  - Shift in consciousness

Legal situation

- International Treaty of Plant Genetic Resources
  - www.planttreaty .org
- Standard Material Transfer Agreement
- UPOV Convention
- Agreement of Application of Sanitary and Phytosanitary Measures
- Biosafety Protocol
- National variety testing
  - New, distinct, uniform, stable (DUS test)
  - Value for cultivation and Use (VCU) tested under high input farming conditions
- National seed law

Legal Situation

- New regulations needed that allow formal and informal seed sector to coexist
- Establishment of new criteria for variety evaluation
- Easier access to plant genetic resources
  - Farmers acknowledged as breeders
  - Momorandum of Understanding between partners, national and international institutions needed
- Ownership of varieties derived from PPB
- Political awareness for importance of access to seed and planting material
- Institutionalisation and upscaling of PPB

Financing of participatory breeding programs

- **Private breeders finance themselves by selling seeds:**
  - In case of increased farm saved seeds income with license is not sufficient
  - Shift in breeding towards few profitable cultures and hybrids
  - Association of companies → closed club varieties
  - Patenting instead of variety protection →loss of breeders' privilege
  - Concentration on seed market→ dependence on global companies →limited access to genetic resources
- **Foundations:**
  - Often only short term sponsorship (1-3 y), only partly financed (GZPK: up to7 private foundations) → uncertain, time consuming
- **Price increase on final product:**
  - Consciousness of consumer, communication of additional value (Demeter)
- **Public support (is decreasing steadily):**
  - Preservation of agricultural diversity and freedom of choice (e.g. GMO free)

→ Sustainable food security and food

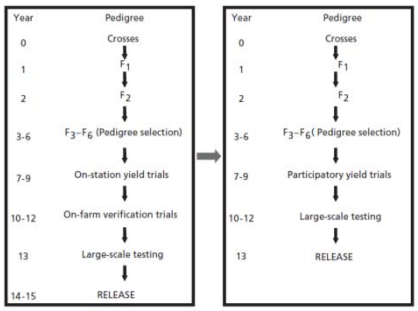
Experience after 3 years of participatory barley breeding in Syria

- **Farmers were able to handle large number of entries, develop oown scoring method**
- **Farmers select for specific adaptive traits**
- **Diversity was higher among farmers' selection in own fields than on station evaluation and also higher than breeders' selection on station or on farm**
- **Farmers and breeders used almost the same selection criteria**
- **Farmers were slightly more efficient to identify highest yielding cultivar in own fields than breeders**
- **Breeders were more efficient selection on station irrigated, while farmers were more efficient in on station selection under low rainfall conditions**

Ceccarelli et al. 2010

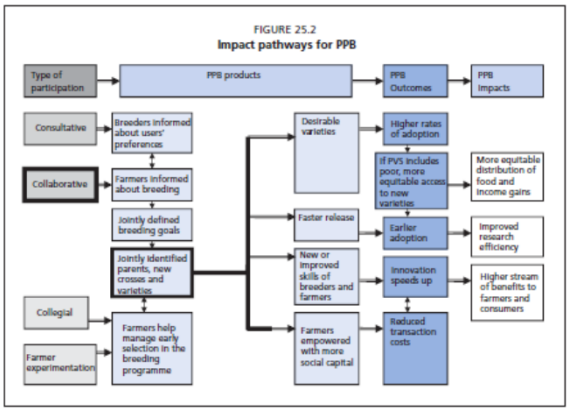
Shortening of breeding process

Schematic representation of a conventional plant breeding programme of a self-pollinated crop based on a classical pedigree method (left): all the phases before the On-farm Verification trials are conducted on research station. On the right, the same programme conducted in a participatory mode



Ceccarelli 2009

FIGURE 25.2
Impact pathways for PPB



Jacqueline Ashby 2009

Greatest impact of PPB

- **Demand of farmers, traders, consumers poorly understood or not recognized by formal seed sector**
- **High degree of risk and uncertainty**
  - Volatile or emerging markets
  - Climate change
  - Very diverse cultivation management or stress environment
- **Wish of producers and stakeholders or even larger part of society to have control over food system**
  - Proprietarity of seed
  - Introduction of plants into food chain (GMO)

→ Changes the organisation and costs of breeding process and technology management

→ Improves trust in research, research efficiency; enhances productivity and welfare of farmers, traders & consumers

Thanks a lot for your attention

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