DIVERSIFOOD

Embedding crop diversity and networking for local high quality food systems

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Lead Beneficiary: Véronique Chable
Responsible author: Véronique Chable & Frederic Rey
Additional author: Riccardo Bocci, Micaela Colley, Ambrogio Costanzo, Carlo Fadda, Isabelle Goldringer, Monika Messmer, Edwin Nuijten and Bernadette Oehen.

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- ☒ **PU:** Public (must be available on the website)
- ☐ **CO:** Confidential, only for members of the consortium (including the Commission Services)
- ☐ **CI:** Classified, as referred to in Commission Decision 2001/844/EC

Rennes
France
10-12 December
2018

Final Congress

Cultivating diversity and food quality

PROCEEDINGS

What is DIVERSIFOOD?

DIVERSIFOOD is a European project aiming at enriching cultivated biodiversity, by testing, renewing and promoting underutilized or forgotten crops. Through multi-actor approaches, it supports the spread of a new food culture, based on diverse, tasty and healthy food.

www.diversifood.eu

DIVERSIFOOD

DIVERSIFOOD Congress 2018

'Cultivating Diversity and Food Quality'

10-12 December, Rennes, France

Introduction

Véronique Chable[1], Frédéric Rey[2], Ambrogio Costanzo[3]

[1] INRA de Rennes, France, www.rennes.inra.fr/sad-bcrp, veronique.chable@inra.fr

[2] ITAB (Institut Technique de l'Agriculture Biologique), France, www.itab.asso.fr , frederic.rey@itab.asso.fr

[3] Organic Research Centre, UK, www.organicresearchcentre.com, ambrogio.c@organicresearchcentre.com

DIVERSIFOOD is a European project aiming to enrich cultivated biodiversity by testing, renewing and promoting underutilized or forgotten crops. Through multi-actor approaches, it supports the spread of a new food culture, based on diverse, tasty and healthy food.

This event is the final congress of DIVERSIFOOD (2015-2019). DIVERSIFOOD results and key lessons will be shared, covering complementary approaches connected with crop diversity for resilient sustainable food systems:

- Underutilized/forgotten crops: multi-actor and on farm evaluation
- New approaches of plant breeding for diversified and sustainable farming systems
- Community biodiversity management
- Diversity and sustainability within food systems: new relationships among actors
- Paradigm shift for multi-actor and transdisciplinary research

This scientific Congress is opened for external oral speakers and/or poster presentations, to better connect sister projects and researches with DIVERSIFOOD outputs.

This congress will provide inputs to shape DIVERSIFOOD messages for the future, on how to better embed crop diversity for resilient sustainable food systems and move toward a real socio-ecological transition.

Diversifood final congress has been designed by the consortium as a platform to share with a large community, results, issues and perspectives. It is based on two main and associated hypotheses:

(1) embedding cultivated diversity in the European territories is the foundation of sustainable and resilient food systems,
(2) the ultimate goal of a resilient agricultural system is to provide high quality food.

Our food quality concept has been developed as a broad concept to enhance all forms of quality from seed to market. Thus, food quality covers a wide range of traits that are defined in the context of sustainable and healthy diets and local food culture. These traits are also covering ethical and social values, nutritional and taste characteristics, and the respect of natural processes. DIVERSIFOOD has shown that developing crop diversity in the fields cannot be dissociated from ensuring all forms of qualities in the plate.

DIVERSIFOOD final congress will reflect all project activities and methodological developments following our multi-actor research organisation as a red thread about:

(1) Evaluation of underutilized/forgotten crops,
(2) New approaches of plant breeding for diversified and sustainable farming systems,
(3) Cultivated diversity management within Community Seed Banks,
(4) Relationships among actors involved diversity and sustainability within food systems and
(5) Research organisation for the paradigm shift toward a "life-oriented" paradigm to boost diversity at all levels within a holistic perspective.

For all these topics, crop and food system diversity have been explored considering different sources of knowledge and integrating objectives for environmental and social sustainability. During the congress, sister projects and researches will expand DIVERSIFOOD outputs to better embed crop diversity for resilient sustainable food systems and move toward a real socio-agro-ecological transition.

Thanks to the event, the DIVERSIFOOD conceptual context will be also strengthened by key-note speakers who will provide inputs to boost and complete DIVERSIFOOD messages for the future. Michel Pimbert (from Coventry University in UK) will highlight the main institutional, methodological, and policy challenges for a transformative paradigm change in the production of knowledge for diversity and sustainable food systems. He

will provide thoughts to democratize the production of transdisciplinary knowledge to expand the construction of agroecological skills for enhanced biocultural diversity in food systems.

Micaela Colley (from the Organic Seed Alliance in the USA) will examine many parallelisms that exist between the United States (US) and Europe regarding the motivations, initiatives and emerging models for organic seed systems development. Differences in governance, history, and social factors impacting progress will also be highlighted.

Philip Howard (from Michigan University in the USA) will expand the DIVERSIFOOD perspective by reminding us the most dominant trends in food and agricultural systems toward specialization and uniformity, despite a long list of negative impacts that typically result. Although counter-trends are currently quite small, some are growing very rapidly fostering decentralization, cooperation and transparency. These efforts are critical for maintaining a sufficient reservoir of knowledge, skills and plant and animal diversities to replace uniform food systems.

For the last day of the congress, you are invited to farm visits that will be followed by two parallel workshops:

- Two farmers based in the surroundings of Rennes (Brittany), involved in crop diversification and on-farm seed production will explain and demonstrate how they integrate all activities from seed to products, aiming at producing high quality produces for local markets. Both are organic farmers, one mostly arable, the other a vegetable grower.
- One workshop will associate LIVESEED partners and other H2020 teams (e.g. ReMIX) to better conceptualise how to fit organic plant breeding in the IFOAM principles. The key hypothesis to explore is that plant breeding is not only matter of efficiency, but it also entails ethical aspects such as food and seed sovereignty and food quality. This workshop aims to develop a shared vision of organic and system-based breeding as an overarching approach to integrate different breeding strategies and tools, and entrepreneurship, but also a change in attitude based on corporate responsibility, circular economy and true-cost accounting, and fair and green policies.
- A second workshop will brainstorm and explore how to boost the transition to more sustainable food systems through a multi-actor and transdisciplinary approach. This approach has a strong potential to achieve this outcome, but it cannot be funded only through short terms projects. We need to collectively develop a long term strategy and to find adapted means to implement the life-oriented paradigm. To deal with the complexity of real societies, we need a transition from the proofs-of-concept within EU projects towards a more systematic deployment. Alternative organisational and funding models need to be developed to produce effective impacts at a significantly larger scale.

We ultimately hope that this congress will consolidate a new research community closely linked to practitioners, for agroecological transition and for the revival of cultivated biodiversity. Connecting diversified knowledge and common wills will boost the embodiment of a life-oriented paradigm.

Programme

Day 1 – 10 December 2018

10:00	Arrival and registration	
11:00	**Welcome and introduction**	*Veronique Chable, project coordinator, INRA, France*
11:20	**Session 1: Opening session - Diversity and sustainability within food systems**	
	Keynote- Transforming research for diverse and sustainable food systems: a paradigm shift for multi-actor and transdisciplinary research	*Michel Pimbert, Executive Director of the Centre for Agroecology, Water and Resilience, UK*
	Discussion	*Moderator : Riccardo Bocci, RSR*
12:30	Lunch	
14:00	**Session 2: Underutilized/forgotten crops: multi-actor and on farm evaluation**	
	Keynote and moderation	*Ambrogio Costanzo, ORC, UK*
	My poster in 3 min. - Value chain involvement	
	Participatory assessment of local and traditional varieties of wheat in South Spain	*Maria Carrascosa, RAS, Spain*
	Re-discovering ancient wheat populations for organic farming in Hungary	*Dóra Drexler, ÖMKI, Hungary*
	My poster in 3 min. -Screenings	
	Lathyrus sativus and L. cicera germplasm characterization and breeding	*Diego Rubiales, CSIC, Spain*
	Antinutritive ingredients in grain legume species for organic fodder	*Gilles Altmann, IBLA, Luxembourg*
	Resistance screening of pea against a complex of root pathogens	*Lukas Wille, FiBL, Switzerland*
	The Honeycomb Selection Designs in Participatory Breeding trials with cowpea	*Dionysia Fasoula, ARI, Cyprus*
	My poster in 3 min. - Biological insights	
	Microbial communities and plant breeding: challenges and perspectives	*Michalis Omirou, ARI, Cyprus*
	Chickpea genotypes response on drought and its impact on mycorrhizal symbiosis	*Athanasia-Eleni Kavadia, ARI, Cyprus*
	My poster in 3 min. -Mobilising diversity	
	Mobilising still diversity for minor cereals in West of France	*Estelle Serpolay, ITAB, France*
	Roundtable & Plenary Discussion	
15:35	Coffee break	
16:05	**Session 3: New approaches of plant breeding for diversified and sustainable farming systems**	
	Keynote and moderation	*Isabelle Goldringer, INRA, France*
	Oral- Evolutionary Participatory Breeding of bread wheat for organic farming in Italy	*Bettina Bussi and Matteo Petitti, RSR, Italy*
	Oral- Culinary Breeding: expanding participatory selection to chefs and kitchens	*Julie Dawson, Univ. of Wisconsin-Madison, USA*
	My poster in 3 min.	
	Participatory on-farm breeding for diverse and adapted wheat mixtures	*Gaëlle van Frank, INRA, France*
	Revisiting Vicia faba breeding criteria to include functional floral traits	*María Jose Suso, ISA, Spain*
	Comparison of two strategies to increase intra-varietal diversity	*Estelle Serpolay, ITAB, France*
	Development and characterization of barley populations for sustainable agriculture	*Lorenzo Raggi, UNIPG, Italy*
	Efficient methods to develop new sweet corn cultivars for organic systems	*Bill Tracy, Univ. of Wisconsin-Madison, USA*
	Roundtable & Plenary Discussion	
17:45	**Poster session**	
18:30	End of day 1	
19:30	Social Dinner in the evening + live music show	

Day 2 - 11 December 2018

08:30	**Session 4: From on farm conservation to Community biodiversity management**	
	Keynote and moderation	*Riccardo Bocci, RSR, Italy*
	Oral- Tools for community biodiversity management	*Regine Andersen, FNI, Norway*
	Oral- From variety selection practices to ecological justice	*Corentin Hecquet , Univ. de Liège - SEED, Belgium*
	My poster in 3 min.	
	Monitoring On-Farm Diversity in the United States	*Cathleen McCluskey, Univ. of Wisconsin-Madison, USA*
	A modeling approach for on farm crop diversity management	*Abdel Kader Naino Jicka, INRA, France*
	Management of plant health and crop diversity – a case study	*Stephanie Klaedtke, Univ. de Liège - SEED, Belgium*
	Conservation and usage of chestnut biodiversity: a case study of partnership research	*Cathy Bouffartigue, INRA, France*
	Mapping European CSAs' Practices for Cultivated Biodiversity	*Jocelyn Parot, INRA, France*
	From Cosmopolitan maize to Identitarian maize: collective management of maize landraces in France and Italy	*Marianna Fenzi, INRA, France*
	Governance and organizational models of informal seed systems in Italy	*Riccardo Franciolini, RSR, Italy*
	Roundtable & Plenary Discussion	
10:05	Coffee break	
10:35	**Session 5: Lessons learnt from value chains studies in Diversifood: factors in support and hindering their success**	
	Keynote and moderation	*Bernadette Oehen, FiBL, Switzerland*
	Oral- Embedding food diversity in supply chains – Experience of eight European case studies	*Anna Sellars, ORC, UK*
	Oral- Ancient cereals in modern times: is there a momentum for underutilised cereals?	*Boki Luske, LBI, NL*
	My poster in 3 min.	
	Communication and Label Concept for Underutilized Crops: Checklist	*Philipp Holzherr, PSR, Switzerland*
	Peasant seeds at the test of identification signs	*Pierre Rivière, RSP, France*
	The potential impact of crop species diversity on food sales in local markets	*Marjo Keskitalo, LUKE, Finland*
	Consumer preferences for vegetables from participatory on-farm breeding networks	*Claudia Meier, FiBL, Switzerland*
	Roundtable & Plenary Discussion	
12:05	Lunch and Poster session	
14:00	**Session 6: Paradigm shift for muti-actor and transdisciplinary research**	
	Keynote- A holistic multi-actor approach to agrobiodiversity enhancement	*Edwin Nuijten, LBI, NL*
	Oral- Plant breeding as a design activity to create the plant resources of agroecology	*Laurent Hazard, INRA, France*
	Oral- NOVIC: A Participatory Project to Trial and Breed Vegetable Varieties for Organic Systems	*Bill Tracy, Univ. of Wisconsin-Madison, USA*
	My poster in 3 min.	
	Participatory ideotyping for organic and locally adapted wheat variety mixtures	*Emma Forst, INRA, France*
	Seeding the Green Future – Participatory organic cotton breeding	*Monika Messmer, FiBL, Switzerland*
	LIVESEED boosting organic seed and plant breeding across Europe	*Monika Messmer, FiBL, Switzerland*
	Paradigm shift for muti-actor and transdisciplinary research	*Veronique Chable, INRA, France*
	Roundtable & Plenary Discussion	
15:30	Coffee break	

16:00	**Session 7: Closing session - toward a socio-ecological transition: Diversifood messages for the future**	
	Keynote speaker: "grand témoins" of the congress	*Micaela Colley, OSA, USA*
	Keynote- Cultivating diverse food systems in the shell of the uniform: power relations and transitions to sustainability	*Phil Howard, MSU, USA*
	Roundtable & Plenary Discussion	
17:30	Conclusion by Veronique Chable, project coordinator, INRA, France	
17:40	End of day 2	

Day 3 - 12 December 2018 – Farms visits & workshops

09:00	**Farm visit 1** diversified arable crops and on farm transformation, biodynamic production (2nd generation)	**Farm visit 2** vegetable crops (cabbage collection) and on farm seed production (80% of the farm needs)
12:00	Lunch	
13:30	**Workshop 1 on financing participatory and multi-actor research (organised by Diversifood)** *Concept note: https://symposium.inra.fr/diversifood2018/Media/Fichier/Day-3-Concept-note*	**Workshop 2 on system based breeding concept (organised by Liveseed project)** *https://link.springer.com/article/10.1007%2Fs13593-018-0522-6*
16:30	End	

Sommaire

Session 1: Opening session

Diversity and sustainability within food systems

Keynote

Transforming research for diverse and sustainable food systems: a paradigm shift for multi-actor and transdisciplinary research

Michel Pimbert

Professor of Agroecology and Food Politics and Director

Executive Director of the Centre for Agroecology, Water and Resilience (CAWR), Coventry University, Ryton Gardens, Wolston Lane, Coventry, CV8 3LG, United Kingdom

E-mail: michel.pimbert@coventry.ac.uk

The regeneration of biodiversity-rich food systems is now a global priority in the search for more sustainable, resilient and socially just futures. In this context, the science and practices of agroecology offer many opportunities to increase the genetic, species, ecosystem and landscape diversity of food and farming systems within specific territories and at multiple scales. Given the important role which vernacular and farmers' knowledge play in agroecological innovations for diversity (genetic, species, ecosystem, economic and cultural diversity) there is a need for a fundamental shift towards multi-actor and transdisciplinary research. This calls for a radical re-orientation and re-organisation of current research and development (R&D) for food and agriculture. Most notably, the construction of technical and policy-related knowledge for agroecology and enhanced biocultural diversity in food systems should be more actively shaped by food producers and consumers rather than by scientific experts and professionals alone.

A two-pronged approach to democratizing the production of transdisciplinary knowledge is proposed here: (1) strengthening horizontal networks of grassroots self-managed research and innovation for diverse food systems; and (2) fundamentally transforming and democratizing public research institutions and universities. Depending on context and history, one approach may be favoured over another. However, when these two approaches are used in complementary and mutually reinforcing ways this can significantly expand the construction of agroecological knowledge for enhanced biocultural diversity in food systems. This paper highlights some of the main institutional, methodological, and policy challenges for a transformative paradigm change in the production of knowledge for diversity and sustainable food systems.s

Session 2

Underutilizated/forgotten crops: multi-actor and on farm evaluation

Keynote

Participatory evaluation of underutilised crops: diversity of plants, diversity of people

Ambrogio Costanzo[1],

[1] Organic Research Centre, UK, www.organicresearchcentre.com, ambrogio.c@organicresearchcentre.com

Key words: crop descriptors, agroecosystem performance, production, quality, agro-biodiversity

Background

Throughout history, thousands of plant species have been domesticated and used in agriculture. DIVERSIFOOD has worked to build a knowledge basis, aimed to provide a central source of information on a wide range of crop genetic resources that are currently underutilised and/or could form the basis of new cropping approaches to respond both to climate change and to social changes in food requirements and uses. The focus is not on the plants, but rather on the process to build opportunities across a wide range of neglected or unexplored resources.

A working definition of underutilised crops

This work started from revising existing knowledge and agreeing a working definition of what underutilised crops are: Plant genetic resources with limited current use and potential to improve and diversify cropping systems and supply chains in a given context. This definition clarifies that the DIVERSIFOOD approach to evaluate genetic resources is therefore not aimed at assessing genetic potentials per se. It is rather aimed at understanding the actual performance of genetic resources, in term of the benefits they can provide, in given contexts, be they specific pedo-climatic or socio-economic. Therefore, underutilised crops are not classified in terms of species, but rather in term of which challenge their (re)introduction can pose, for which three main cateogories were identified: (i) rediscovery of neglected species, with the minor cereals einkorn (Triticum monococcum), emmer (Triticum dicoccon), rivet wheat (Triticum turgidum) as typical examples; (ii) re-extending areals of common species, with e.g. chickpea (Cicer arietinum) being tested in the British Isles; (iii) (re)introduction of neglected or alternative germplasms as e.g. Open Pollinated Varieties (OPVs) in maize (Zea mays), brassicas (Brassica oleracea) and tomatoes (Lycopersicon esculentum), which are currently all hybrid-dominated crops. Beyond the above examples, the activities of WP2 span across testing landraces of buckwheat (Fagopyron esculentum), graftings of chestnut trees (Castanea sativa), accessions of lupins for their attitude to grow in intercropping with oats and of wheat (Triticum aestivum, Triticum durum), field beans (Vicia faba) and fodder legumes to grow in mixed cropping. It is worth specifying that a single genetic resource can fall under multiple categories at a time, or under different categories depending on the context.

How to evaluate underutilised crops

Diversifood has undertaken a series of parallel experiments, all testing the same underlying hypothesis expressed in the "working definition": that reintroducing genetic resources with a status of underutilisation can trigger benefits in provisioning agroecosystem services and supporting local, high-quality value chain, in the overall framework of agroecological systems.

These experiments were conceived as an exploration of genetic resources in the context of specific, local agro-environmental or market challenges and opportunities, often in link with farmers' initiatives. Genetic resources have been sourced from a variety of both informal and formal ex-situ and in-situ collections, as those maintained by the partner ProSpecieRara, and from public seed banks, as e.g. the John Innes Centre in the UK, creating a unique merging and on-farm deployment of materials from very different sources. Trial protocols have been developed to break down crop "evaluation" into four main dimensions (Fig. 1), strictly connected with one another, yet all with a value of their own: (i) crop descriptors, i.e. those phenotypic traits useful to identify a genetic resource; (ii) agroecosystem performance, as a driver of environmental fitness; (iii) productive performance, as a driver of the yield potential; (iv) quality performance, as a driver of success in local, high-quality value chain.

Many species have been tested as deeply embedded in the local environmental and social contexts where the initiative for every experience has been taken, as e.g. chestnut in Ariège (France) or tomatoes in Styria (Austria), whereas in other cases the evaluation was less limited in space and more embedded into the common socio-economic goal of diversifying supply chains, as for minor cereals – those neglected, sturdy relatives of wheat – namely emmer, einkorn and rivet wheat, as well as OPVs of broccoli, that have been systematically tested in several locations, with a set of common accessions and thorough field and quality characterisation. Many

experiments also include analyses at the level of health-promoting compounds in the produce, as well as at the level of the microbiome.

What we have learned

As far as crop descriptors are concerned, two main remarks emerged. First, certain traits reappear that, during the course of modern breeding, were lost. The wide diversity also included undesirable traits, that have been bred against and might also have played a role in the abandonment of certain phenotypes. A typical example is the extreme straw height of certain winter cereals that generates problems of lodging. At the same time, cereals with similar straw height were found to differ significantly in terms of lodging susceptibility, suggesting that the existing wide genetic diversity also includes the resources to counteract the negative effects of certain characteristics. Second, single genetic resources show considerable within-crop phenotypic diversity, which can either be part of their genetic structure, being them landraces or OPVs or composite cross populations, or result from intentional or even accidental mixtures, as observed in certain entries of rivet wheat which included considerable amounts of bread wheat.

Agroecosystem performance was evaluated under different angles, mostly looking at weed competitiveness, pest and diseases resistance and abiotic stress tolerance. In some cases, the focus was really specific and set on e.g. resistance to a certain disease, whereas in others the focus was broader and set on the overall fitness in marginal conditions. The overall outcome is that agroecosystem performance of a same genetic resource can vary greatly depending on where it is grown and must therefore be looked at a very local scale. This reinforces the importance of deploying and testing genetic resources in multiple farms rather than in centralised research stations.

Productive performance highlighted a, perhaps expected, trend: yield of underutilised crops can be a serious limiting factor, as the tested material can be either low-yielding or difficult to harvest, but, in many cases, can be a relief for marginal conditions. Species as einkorn, emmer or rivet wheat can thrive where their commonly grown closest relatives (e.g. durum or bread wheat) are not a viable option. This is one of the key benefits expected from underutilised crops: that they can be a valuable option for areas that would perhaps be abandoned if only relying on widely available seeds.

Quality performance was as well evaluated under different angles, namely (i) processing quality, (ii) nutritional and nutraceutical quality, (iii) organoleptic quality and (iv) intangible value. Main highlights under these points are that a diversity of crops triggers a diversity of products that needs adaptation in both the processing and the methods and concepts to assess their quality. This in not to be seen as a limitation in itself. Grains from minor cereals are not necessarily suited to industrial milling but are an opportunity for e.g. artisanal millers and bakers, whose processing methods are more flexible, to add value to highly nutritious raw materials. Similarly, broccoli OPVs can show higher concentration of health-promoting compounds (as e.g. glucosynolates) than mainstream hybrid without necessarily lower yield. Their phenotypic diversity in shape and sometimes taste of the florets makes them more suited to alternative distribution as direct selling or "farmers' markets" than e.g. supermarkets, at least in the immediate future. Last but not least, the "intangible" value is something not measurable but, yet, not negligible in importance as it builds on the "cultural identity" of a product and can therefore support the development of production and supply chains with values other than yields and revenues.

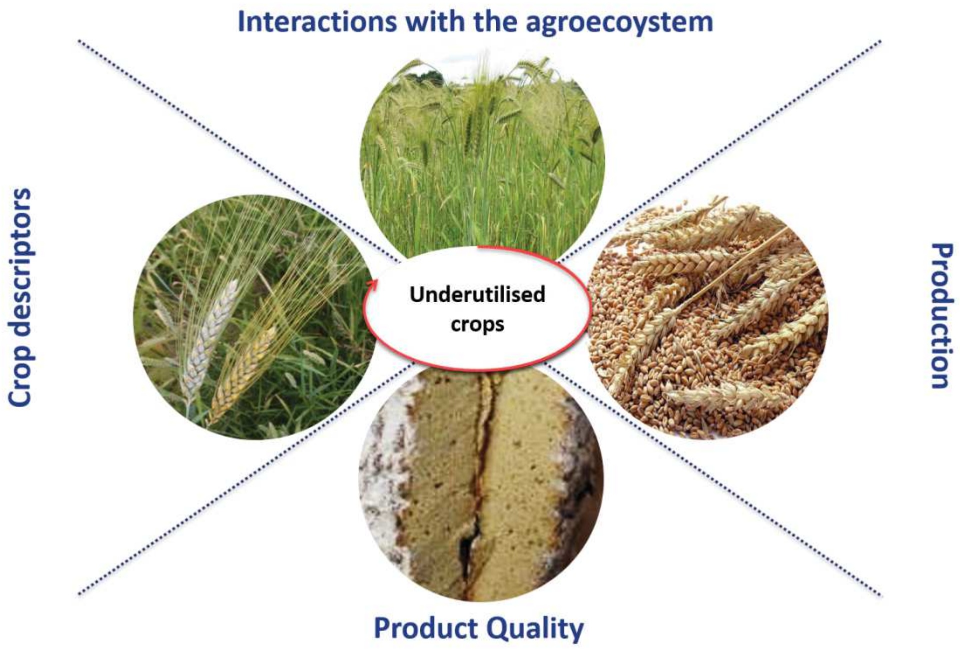

Fig. 1. The four dimensions of evaluation of underutilised crops

Conclusion

The evaluation of underutilised genetic resources in DIVERSIFOOD has triggered at least two levels of innovation. A first level is attempting the introduction of a diversity of species in an agricultural context characterised by standardisation of cropping systems and supply chains and a shrinking species and genetic diversity. A second, more methodological level, is to distribute the evaluation in a diversity of farming environment and communities that can build added value on underutilised crops. The combination of these two levels of innovation has created a steep learning curve for all the actors involved. Our wish is that more communities will want to engage in this learning curve and share the practice of distributing a diversity of genetic resources and embedding their evaluation in sustainable cropping systems and supply chains. The diversity of practices of engaging with evaluation of genetic resources is the key legacy that we want to share and discuss in this session.

Poster in 3 min

Participatory assessment of local and traditional varieties of wheat in South Spain

María Carrascosa-García[1], Salvatore Ceccarelli[2], Alonso Navarro Chaves[1], Maria Pérez Picón[1], Eugenia Roldán[1], José Antonio Fulgado[1]

[1] Red Andaluza de Semillas, Caracola del CIR, Parque de San Jerónimo, 41015 Sevilla, Spain, www.redandaluzadesemillas.org, info@redandaluzadesemillas.org

[2] Rete Semi Rurali, Via di Casignano 25, 50018 Scandicci (FI), Italy.

Key words: landraces, participatory research, durum wheat, bread wheat.

Background

One strategy for increasing diversity in cereal production systems is the introduction of local and traditional varieties. Nowadays, very few varieties of this type are used and, in many cases, they are conserved by old farmers in isolation. In recent years certain groups of farmers have been interested in prospecting and multiplication of cereal cultivated biodiversity, with the aim of reintroducing this interesting material in the agrifood system. The Seed Network of Andalucia (Red Andaluza de Semillas-RAS) has collected this work and taken it a step further, generating morphological, agronomic and organoleptic information on these varieties through participatory methodologies. The use of Participatory Action Research techniques has facilitated the incorporation into the research process of the different actors involved: farmers, bakers, consumers, technicians and researchers.

Characteristics of the varieties assessed

The present paper gathers the work of participatory evaluation in two agroecological farms of Andalusia of 15 traditional and local varieties of wheat, during the crop season 2015/2016, 2016/2017 and 2017/2018.

The methodology used for the development of the research has been, firstly to select the farmers and farms where developing the trials. The chosen farms are placed in Yunquera (Málaga) and Castilblanco de los Arroyos (Sevilla) and are managed by farmers with a deep experience in local variety wheat production. Then, wheat varieties to be tested have been selected. The priority has been to choose those used by farmers collaborating in the project but varieties coming from the National Centre of Plat Genetic Resources and farmers participating in meetings and events organised by RAS have also been included. Through a participatory process, RAS technicians, farmers and DIVERSIFOOD researchers have elaborated a protocol for testing and description, implemented the trials, collected the data and systematize the information.

A specific activity with bakers and consumers have been organised in order to assess bread elaborated with flour of these varieties.

Finally, a record for each variety, with its main characteristics, has been produced. These files will help to communicate better about the characteristics of theses varieties with farmers, processors and consumers and therefore to promote its use.

Acknowledgments

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Poster in 3 min

Re-discovering ancient wheat populations for organic farming in Hungary

Dóra Drexler[1], Marianna Makádi[2], Attila Tomócsik[2], Tímea Jung[1]

[1] ÖMKi, Hungarian Research Institute of Organic Agriculture, www.biokutatas.hu, dora.drexler@biokutatas.hu

[2] University of Debrecen, Institute for Agricultural Research and Educational Farm, Research Institute of Nyíregyháza, Hungary: https://portal.agr.unideb.hu/kutatointezetek/nyki/index.html, makadim@agr.unideb.hu

Key words: emmer, einkorn, landraces, organic, DIVERSIFOOD

Background

In frame of the DIVERSIFOOD Horizon 2020 project we test emmer (*Triticum dicoccon*) and einkorn (*Triticum monococcum*) land races and varieties under organic conditions since 2015 in Hungary. We received 13 emmer and 5 einkorn accessions from Pro Specie Rara, Switzerland, the Plant Diversity Centre, Hungary, the Agricultural Research Centre of the Hungarian Academy of Sciences, Martonvásár, and the Louis Bolk Institute, the Netherlands. 10 of the tested emmer varieties were winter types, 3 spring types. All einkorn varieties were winter types. The same accessions were sown in Hungary, the UK, Cyprus, and the Netherlands. The aim of the trials was to assess the performance of ancient cereal varieties under organic conditions, and to evaluate the potential of their local cultivation based on i) small plot research trials and ii) large plot on-farm participatory tests. The experiments are ongoing; this paper presents the results of the first two years from Hungary.

Methods

Emmer and einkorn accessions were sown at the organic trial site of the Research Institute of Nyíregyháza, on marginal acidic sandy soil. In the 2015/2016 season an incomplete block design was used, and performance assessment was combined with seed propagation for next season. In 2016/2017 we applied a complete block design. We assessed the number of plants in winter and spring, plant phenology, plant height, number of heads, weed coverage, plant pathological status, yield, and thousand kernel weight according to a previously agreed protocol. Statistical analyses were performed using SPSS Version 22 statistics software package. In order to identify the significant differences between groups of variables Kruskal Wallis H test was used. Pairwise comparisons were performed using Dunn's (1964) procedure with a Bonferroni correction for multiple comparisons. To detect differences between the results of the two years, Mann-Whitney U test was applied.

Results

Most of the evaluated emmer and einkorn accessions proved an ability to adapt to the marginal conditions of the Nyíregyháza trial site. One winter emmer accession (GT-2140) was lost during the first year due to its lack of frost hardiness. Differences of winter and spring plant numbers showed a strong natural selection of the populations in the first year. There were no significant differences between the yields of different accessions. Significant differences were, however, recorded between the yields of the two trial years. In case of winter emmer average yields varied between 1.2-3.1 t/ha, in case of spring emmer between 1.6-2.1 t/ha, and in case of einkorn between 1.3-3.6 t/ha. One registered organic einkorn variety (Mv Menket) was bred for short straw and intensive organic cultivation, and thus proved to be very low performing under marginal conditions. Einkorn accessions showed a high level of tolerance against all diseases. Some emmer accessions (e.g. Nödik emmer) were extremely susceptible to yellow rust, even under the arid conditions of the trial site. These accessions cannot be advised for larger scale production. Overall, our experience showed that optimal sowing time is one of the main requirements of a strong stand with high yield production. Seeds of promising accessions were distributed in 2017/2018 to an organic farmer where on-farm data will complement the third year trial results.

Conclusion

Emmer and einkorn accessions tested in this experiment were subject to marginal growing conditions under organic management in East-Hungary. Most accessions showed a good adaptability, although yellow rust, frost hardiness, and sensitivity to sowing date were limiting factors of successful cultivation for some varieties. Weed infestation due to poor coverage proved to be a problem, especially for spring emmer types. Some winter emmer and einkorn landraces outperformed registered varieties in terms of number of plants/m^2 and yield, and can be advised for on-farm testing. First on-farm results will be obtained in 2018. Taking into account the market price of ancient cereals, emmer and einkorn can be a good alternative for organic growers, also on marginal soils.

Poster in 3 min

Lathyrus sativus and *L. cicera germplasm* characterization and breeding

Diego Rubiales[1], María J. González-Bernal[1], Carmen Santos[2], Davide Martins[2], Margarida Sampaio[2], Letice Gonçalves[2], Priscila Pereira[2], Maria C. Vaz Patto[2]

[1] Institute for Sustainable Agriculture, CSIC, Córdoba, Spain, diego.rubiales@ias.csic.es

[2] ITQB NOVA, Universidade Nova de Lisboa, Oeiras, Portugal

Key words: legumes, grasspea, chickling pea, resistance, genetic resources

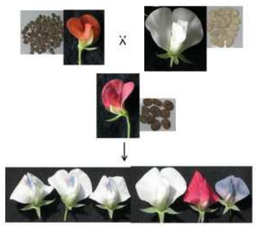
Lathyrus sativus (grass pea) and *L. cicera* (chickling) are ancient legume crops that are largely neglected today in spite of their rusticity and value for food and feed for more sustainable farming systems. We have characterized germplasm collections for agronomic performance under field conditions in different environments and for resistance against a number of diseases under controlled conditions. We have generated RIL mapping populations in both species that are presently under study. Linkage maps for these two species are being developed also with species specific molecular markers in house developed.

In an attempt to increase the variability, interspecific crosses were made between *L. sativus* and *L. cicera* generating valuable pre-breeding material that has been selected over 10 years for fertility, adaptation to Mediterranean environment and resistance to diseases.

This work is contributing to the development of *L. sativus* and *L. cicera* materials with improved adaptation, yield, resistance and nutritional quality, meeting farmer's and consumers' expectations. A cultivar of each species are now submitted for registration to the European catalogue.

Fig. 1: Field trial of *L. sativus* at Alvaizere

Fig. 2: Interspecific cross *L. cicera* x *L. sativus*



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Poster in 3 min

Antinutritive ingredients in grain legume species for organic fodder

Sabine Keßler[1], Evelyne Stoll[1], Hanna Heidt[1], Hannes Schulz[2], Jürgen Heß, Torsten Bohn, Stéphanie Zimmer[1]

[1] Institut fir biologësch Landwirtschaft an Agrarkultur (IBLA), Luxembourg, www.ibla.lu, kessler@ibla.lu

[2] Luxembourg Institute of Science and Technology (LIST), Luxembourg, www.list.lu

[3] Universität Kassel – Fachgebiet ökologischer Land- und Pflanzenbau, Germany, https://www.uni-kassel.de/fb11agrar/fachgebiete-einrichtungen/oekologischer-land-und-pflanzenbau/startseite.html

[4] Luxembourg Institute of Health (LIH), Department of Population Health Luxembourg, www.lih.lu

Key words: antinutritiva, fodder production, Luxembourg, Germany, grain legume species,

Background

About 63% of European protein feedstuff are currently imported, the EC stated in 2018 (EC, 2018). Most grain legumes contain antinutritional substances such as tannins, protease inhibitors, alkaloids and vicine/convicine, depending on cultivars and growth conditions (Ivarsson, 2018; Jeroch, 2016). As livestock health is likely depending on the contents of antinutritional substances in this protein-rich fodder (Jeroch, 2016), the aim of the study is to compare different grain legume species (GLS)(winter and spring faba bean (*Vicia faba*) , winter and spring pea (*Pisum sativum*), blue lupin (*Lupinus angustifolius*) and soybean (*Glycine max*)in order to evaluate their fodder value considering their nutritive and antinutritive contents.

Main chapter

The field trials were conducted in 2012 and 2013 at Karelshaff (KH), Colmar-Berg, in Luxembourg. The site is under organic farming conditions since 2002. The study in Germany was conducted in 2014 and 2015 on the "Hessische Staatsdomäne Frankenhausen" (FH) in Grebenstein which is an experimental station of the University of Kassel (For further site description please refer to Zimmer, 2016 a and b). The field trial was done in a randomized block design with four repetitions. Besides nutrient ingredients, the GLS were analyzed for tannins and trypsin inhibitor as well as alkaloids (lupin, pea) and vicine/convicine (faba bean).
For the Luxemburgish trial, winter and spring faba beans showed the best suitability for producing protein-rich fodder on farm. However, it is important to note that in 2012 and 2013, weather conditions were very favorable for faba beans (Zimmer, 2016a). For the German trial, no clear trend could be discerned in terms of best suitability for production. First results for antinutritive ingredients show that the experimental site and yearly variations have an influence on the content and that they are slightly different from literature values (Jeroch, 2016). The antinutritive factors showed yearly variations for all GLS except of alkaloids and of vicine/convicine in faba beans. Alkaloids were below limits of determination in FH (<0.005 g/100g) and quantification in CA (<0.1 g/100g). Spring and winter faba bean show vicine contents which are in the lower range of literature values for both sites, but concentrations in FH were the double of those in KH. Trypsin Inhibitor for soy bean showed lower concentrations and faba bean only 10 to 20% of those values found in literature. Spring pea and winter pea in KH showed the same tannin concentrations for both years whereas concentrations at FH were the double in the second year. These first results show that data from these on farm trials will give necessary information on the suitability of local GLS as protein-rich fodder. Moreover, the antinutritive factors will be related to the nutritive factors in order to give advice to farmers for production regarding to livestock feeding.

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Poster in 3 min

Resistance screening of pea against a complex of root pathogens

*Lukas Wille[1,2], Bruno Studer[2], Monika M. Messmer[1], Natacha Bodenhausen, Pierre Hohmann[1,]**

[1] Department of Crop Sciences, Research Institute of Organic Agriculture (FiBL), Frick, Switzerland

[2] Department of Environmental Systems Science, ETH Zürich, Zurich, Switzerland

* pierre.hohmann@fibl.org

Key words: genetic diversity, microbiome, plant breeding, rhizosphere, root exudates, soil-borne diseases

Background

Pea (*Pisum sativum* L.) is a valuable protein source for food and feed and represents an ecologically important crop in low-input farming systems around the world. Fungal root diseases can cause severe damage leading up to total yield loss. The lack of adequate resistance in current pea varieties against different root pathogens impede pea cultivation worldwide. Sustainable solutions are needed particularly for organic farmers who rely on this ecologically important nitrogen fixator.

Main chapter

The overall goal of this project is to elucidate the role of rhizosphere-related traits in resistance of pea against fungal root diseases. In a first step, a collection of pea cultivars, advanced breeding material and gene bank accessions were evaluated for resistance in pot-based experiments using naturally-infested agricultural soil. Based on different disease assessments, a subset of susceptible and partial resistant pea genotypes has been identified (**Fig. 1**). Further, the fungal microbiome of infected pea roots has been characterised via 18S rRNA amplicon sequencing (**Fig. 2**). First results show a root community of similarly abundant fungal OTUs (operational taxonimic units), not dominated by a few dominating individuals. This finding points at complex interactions within the fungal community.

Current work aims to (i) identify key pathogens and beneficials and link their spatio-temporal dynamics with different disease resistance mechanisms and (ii) associate pea genomic regions with disease resistance against pathogen complexes. The study will shed light on the complex interactions at the plant-soil interface and promote resistance breeding programmes for legumes.

Poster in 3 min

The Honeycomb Selection Designs in Participatory Breeding trials with cowpea

Dionysia A. Fasoula[1], Michalis Omirou[2], Ioannis M. Ioannides [2]

[1] Agricultural Research Institute, Department of Plant Breeding, www.ari.gov.cy, dfasoula@ari.gov.cy
[2] Agricultural Research Institute, Department of Agrobiotechnology, www.ari.gov.cy, michalis.omirou@ari.gov.cy, ioannide@ari.gov.cy

Key words: landraces, nitrogen fixing bacteria, interplant competition, prognostic breeding

Background

Cowpea is an important crop for Cyprus as it is part of the traditional local cuisine. It is consumed both as fresh pods and fresh or dry beans, and represents a source of a substantial income to farmers, especially the fresh pods harvested in early spring that command the highest prices in the market. The project was initiated after feedback from farmers expressing certain concerns regarding the local cowpea landrace "Argaka". Thus, we took over the study of the within-landrace variability discovering a range of intriguing facts, including the existence of cryptic, non-useful variation, manifested in traits like sensitivity to photoperiod and bareness.

Materials and Methods

Accurate, nonvisual selection for quantitative traits, like pod yield and stability of pod yield over multiple harvests, as well as for the relative above ground and root biomass, was performed at the level of the individual plant using the principles of the prognostic breeding paradigm and the honeycomb selection designs. Every year, about 500 hundred individual plants were uprooted to measure root weight and count the root rhizobia, while also measuring above ground biomass and total pod weight. Farmers visually scored a series of trials comparing the original landrace with the selected lines in a participatory manner in the honeycomb trial and in standard planting density.

Results and Discussion

The results of this breeding program highlighted a range of intriguing facts, including the existence of cryptic, non-useful variation, manifested in traits like sensitivity to photoperiod and bareness. Plants with the above traits consume substantial resources producing a limited number of pods and not during all of the consecutive harvests, which can be up to seven within a period of 3 months. Through the novel selection process, a series of cowpea lines with improved partitioning of resources in pods versus above ground and root biomass is now available for Cyprus farmers. Interestingly, scoring results derived from farmers were in excellent agreement with the results of the data analysis from the Honeycomb trials. Further, cowpea specific symbiotic nitrogen fixing bacteria were isolated and characterized using molecular methods highlighting the importance of focusing on genotype-specific functional microbes.

Conclusions

This study demonstrates that the application of the honeycomb selection designs and the principles of the prognostic breeding strategy are powerful tools that enable selection of high performing and stable genotypes while facilitating the selection of plant-specific, high performing symbiotic nitrogen fixing bacteria.

Figure 1. Field cowpea trials using honeycomb designs

Figure 2. Nodules of nitrogen fixing bacteria in cowpea

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Poster in 3 min

Microbial communities and plant breeding: challenges and perspectives

Michalis Omirou[1], Dionysia Fasoula[1], Veronique Chamble[1], Ioannis M. Ioannides[1]

[1] Agricultural Research Institute, Cyprus, country, www.ari.gov.cy, michalis.omirou@ari.gov.cy

Key words: Plant breeding, symbiotic nitrogen fixing bacteria, mycorrhizal fungi, biodiversity

Background

It is evident that to feed the global population in the decades we should substantially increase the productivity of agricultural ecosystems. At the same time agricultural activity must avoid further deterioration of the environment making food security a great challenge for the scientific community. Plant breeding has been the main tool for the production increase in agricultural systems under the asidoti use of chemical inputs (fertilizates

Plant breeding during the past decades has been performed under high fertilization and intensive crop protection, leading to a substantial decrease of diversity among modern cultivars. The selection of genotypes under these conditions has also affected the ability of modern varieties to establish beneficial associations with soil functional microbial assemblages, like mycorrhizae fungi and symbiotic nitrogen fixing bacteria.

In this presentation we will discuss how functional microbial communities in soils could challenge the needs of future agriculture and why integrated strategies in plant breeding should include soil microbial communities studies.

Material and Methods

Honeycomb designs were used for the evaluation of functional microbial guilds in 7 maize and 13 chickpea landraces as well as 6 local cowpea genotypes. AMF colonization and extraradical mycelium was assessed in roots as previously described (Vierheilig et al., 2005). Plant nutrient content (N and P) in aboveground biomass was determined using standard procedures. Isolation of symbiotic nitrogen fixing bacteria was performed from each cowpea single plant and grown in YMA selective medium. Then more than 100 isolates were screened for their ability to promote cowpea growth.

Results and Discussion

All crops tested exhibited different symbiotic characteristics between them as well as within the same species. For example, the differential response of maize genotypes was associated with mycorrhizal colonization and diversity. In particular, the variation of AMF colonization in 7 different maize landraces was high and ranged between 9 to 70%. However, high AMF colonization was not always reflected to high plant yields. Molecular fingerprinting showed that AMF diversity is partially associated to maize productivity and this is related with the plant genotype. Similar findings were noticed in Cyprus chickpea local landraces where high yield variability was noticed between genotypes. The best performing genotype (Gen1) was significantly correlated to AMF colonization and P content. Interestingly, genotype (Gen 2) showed a significant correlation with P content but not with AMF colonization. This genotype had the lowest yield and the ERM measured was strongly associated with biomass production and P content suggesting a genotype specific plant-fungal association. Selected symbiotic NFB showed to determine AMF colonization as well as diversity suggesting complex interactions among functional microbial groups that are associated to cowpea performance (Omirou et al., 2016).

Conclusion

So far results from different experiments and projects suggest that functional microbial communities are of paramount importance for plant performance particularly under stressful conditions. Selection, characterization and application of these functional microbial guilds along with their associated genotypes could a useful strategy to improve plant performance. Apparently, studying soil microbiomes and their intimate relationship with plants during National breeding programs it is expected to improve the resilience of agricultural ecosystems productivity in a climate-changing environment.

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Poster in 3 min

Chickpea genotypes response on drought and its impact on mycorrhizal symbiosis

Athanasia-Eleni Kavadia[1], Michalis Omirou[1], Dionysia Fasoula[1], Ioannis M. Ioannides[1]

[1] Agricultural Research Institute, Cyprus, country, www.ari.gov.cy , akavadia@ari.gov.cy

Key words: Chickpea, mycorhhizal colonization, drought,

Background

Drought conditions are prevalent in the Mediterranean region and dramatically affect the sustainability of agricultural ecosystems. Arbuscular mycorrhizal fungi (AMF) play a crucial role in plant growth and development, and nutrient uptake. In addition, plants that are AMF colonized prove to be more adapted to biotic and abiotic stress factors, such as root pathogens, drought, high soil temperature and saline soil.

Material and Methods

Pot experiments conducted in a complete randomized design (CRD) where two chickpea genotypes were grown at two different water level treatments (normal irrigation conditions-W1 and deficit irrigation-W2). The effect of drought conditions on plant biomass and plant nutrient content (nitrogen, phosphorus, and potassium) was assessed. Mycorrhizal colonization, extraradical mycelium growth and their effect on chickpea genotypes were also assessed.

Results and Discussion

Different water levels and sampling periods, significantly affected the performance of mycorrhizal colonization ($p<0.01$). Normal irrigation conditions demonstrated a substantial increase in AMF root colonization, comparing to limited irrigation. Both, different sampling periods and plant genotype, affected significantly the dry matter production of chickpea plants. Genotypes showed a differential response to water deficit. In particular, low water availability, in case of genotype 365, resulted in a substantial increase of biomass, comparing to normal irrigation. This was associated to AMF colonization and P content. Pearson Correlation showed a positive and significant relationship ($p<0.05$) between dry biomass accumulation, AMF colonization (r=0.84), and P content (r=0.76). Plant genotype, and water availability, had a significant effect on nutrient content in above ground biomass. Plants grown under normal irrigation conditions exhibited higher nitrogen content, during the course of the experiment, compared to plants grown under drought conditions, which was genotype depended ($p<0.02$). A trend of higher phosphorus content was noticed under normal irrigation treatment during time, in both genotypes. On the contrary, different water levels significantly affected potassium content. Plants grown under well water conditions had higher potassium concentration. The influence of all factors (sampling periods, genotype and water treatment) on extraradical mycelium growth was not statistically significant. High phosphorus content was linked to high potassium content and high AMF colonization.

Conclusion

This study suggests that chickpea response to drought stress is related to plant genotype and its ability to establish efficient AMF symbiosis.

Poster in 3 min

Mobilising still diversity for minor cereals in West of France

Serpolay-Besson Estelle[1], Villard Anne-Lise[2], Leprêtre Franck-Emmanuel[3], Chable Véronique[2]

[1] ITAB (Institut Technique de l'Agriculture Biologique), France, itab.asso.fr, estelle.serpolay-besson@itab.asso.fr

[2] INRA de Rennes, France, www.rennes.inra.fr/sad-bcrp, veronique.chable@inra.fr

[3] Triptolème, France, www.triptoleme.org, fe.lepretre@gmail.com

Key words: diversification, genebanks, minor cereals

Background

For more than 15 years, French organic farmers have been committed to on-farm plant breeding to increase diversity from the fields to the markets (Chable et al, 2014). The first experiences were initiated with soft wheat to provide high quality flour for traditional bread baked with natural sourdough. In order to increase the agroecosystem diversity to enhance sustainability of agroecosystems and to diversify the products available on the market, farmers, millers, bakers and others actors of the food chain aim to enlarge the panel of cultivated crops and the diversity of available varieties. But how can such processes be initiated when traditional landraces or populations are not cultivated anymore in France? Which varieties to start with? Thanks to their previous experiences, actors of the organic food chain have become curious about the diversity stored ("sleeping") in the genebanks and it was proposed to explore this still diversity. Three elements condition our activities (INRA-ITAB research team) when trying to rediscover it : (1) most of the accessions of landraces stored in genebanks are not known, only date and place of collection are usually mentioned (passport data), and (2) we need to organise the evaluation taking into account the huge number of available accessions with very few available seeds per sample and (3) the populations provided by genebanks have become genetically homogeneous. Then, the research question is how to create new diversified populations adapted to organic agriculture and high quality products? Within Diversifood, we started with 3 species (rivet wheat, buckwheat and spelt), thanks to collaborations with a local project about minor cereals in the West of France.

Main chapter

The process of mobilising the "still" diversity from genebanks for living agriculture is built on several steps: (1) collecting information about the history of the crop, (2) gathering a large panel of samples of accessions from diverse origins, (3) multiplying and observing them in one place on basic phenotypic traits for 2 years (increasing of seed quantity, starting adaptation), (4) creating new diversified populations by bulking several complementary accessions (with common traits of interest) for on-farm evaluation.

Rivet wheat: 180 accessions from Spanish genebank were observed in 2017 and 2018. At least one early population, one late population, one "miracle" (branched spikes) population and one vitreous populationwill be created after the 2018 harvest.

Buckwheat: 199 populations from 10 different European genebanks were observed in 2016 and 3 diversified populations were created: pink flowered, early and large seeded ones. Multiplication has started in Spring 2018.

Spelt: 30 landraces from 5 European genebanks were sown in 2017. Observations are on-going.

For each species, all the accessions will also be mixed to create "giant" populations.

Once on farm, these diversified populations are supposed to have a great potential for adaptation. The perspective is to involve farmers during multiplication to collect and specify their expectations in order to shape the new populations according to their needs..

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Poster

Conservation networking for Euro-Mediterranean plant agrobiodiversity

Nigel Maxted[1], Béla Bartha[2], Adam Drucker[3], Ehsan Dulloo[3], Jenny Hawley[4], Jose Iiriondo[5], Ben McCarthy[4], Valeria Negri[6], Lorenzo Raggi[6], María Luisa Rubio Teso[5], Theo J.L. van Hintum[7], Stephan Weise[8] and Shelagh Kell[1]

[1] School of Biosciences, University of Birmingham, Birmingham B15 2TT, UK, n.maxted@bham.ac.uk

[2] ProSpecieRara, Basel, PC-Konto: 90-1480-3, Switzerland.

[3] Bioversity International, Via dei Tre Denari 472/a, 00057, Maccarese, (Fiumicino), Roma, Italy.

[4] Plantlife, Salisbury SP1 2AP, UK.

[5] Departamento de Biologı´a y Geologı, Universidad Rey Juan Carlos, 28933 Mostoles, Spain

[6] Dipartimento di Scienze Agrarie, Alimentari e Ambientali, Università degli Studi di Perugia, Perugia, Italy.

[7] Centre for Genetic Resources, Wageningen University and Research Centre, Wageningen, The Netherlands.

[8] Leibniz Institute of Plant Genetics and Crop Plant Research, Gatersleben, 06466 Stadt Seeland, Germany

Key words: Plant genetic resources, *In* / *ex situ* conservation, Conservation networks, Crop improvement, Food security

Background

The Euro-Mediterranean region is important for its diversity of crop species and their wild relatives—including several cereals and legumes (e.g., wheat, oat, chickpea, lentil, pea and faba bean), fodder and forage crops (e.g., lucerne, white clover and sugarbeet), and many vegetables, fruits, nuts, herbs and oils (e.g., brassicas, lettuce, grape, almond, pistachio, sage and olive). Local varieties of crops (or landraces) and populations of crop wild relatives (CWR) are essential for food, nutrition and economic security, both due to their importance for farmers and local communities and as sources of genetic diversity for crop improvement. This diversity is of particular value as insurance against the impacts of global change, while at the same time being threatened by the same impacts. These include: loss, modification or fragmentation of natural habitats; intensive and unsustainable farming practices; the wide-ranging impacts of climate change on the environment; and the cultivation of modern cultivars to the exclusion of local crop varieties.

Main chapter

To increase food production sustainably in the face of these challenges requires significant additional plant diversity beyond that currently conserved ex situ. To achieve this, strategies for systematic in situ conservation of these plant genetic resources (PGR) need to be implemented throughout the region. The EU-funded project, 'Farmer's Pride' (www.farmerspride.eu) is meeting this challenge by establishing a network for in situ conservation of PGR that brings together stakeholders and sites across the region and coordinates actions to conserve diversity for crop enhancement and adaptation in the future. As part of this work we are: a) defining and promoting best practices for the management of plant diversity in wild and cultivated populations; b) showcasing how *in situ* and *ex situ* conservation actions can be effectively integrated; c) creating tools to manage the complex information associated with *in situ* conservation; d) engaging with plant breeders, farmers and other PGR users to identify the most important traits to meet future agricultural and market needs; e) undertaking analyses to predict which populations are most likely to contain these traits; f) creating an infrastructure to promote and facilitate access to *in situ* conserved diversity; g) building stronger and long-lasting local, national and international seed networks; h) investigating the suitability of the current policy environment to support the governance structure of the network; i) identifying cost-effective strategies and policies to improve PGR conservation and use in the region; and j) establishing a dialogue to communicate our recommendations to policy-makers.

Poster

Multiple-criteria approach to select drought-resistant maize populations

Maria Catarina Bicho[1,2], Mara Lisa Alves[1], Susana Trindade Leitão[1], Emanuel Ferreira[3], Pedro Mendes-Moreira[3], Joaquim Miguel Costa[1,2], Maria Carlota Vaz Patto[1]

[1] ITQB-NOVA, Portugal, www.itqb.unl.pt, cpatto@itqb.unl.pt

[2] ISA-ULisboa, Portugal, www.isa.ulisboa.pt

[3] IPC-ESAC, Portugal, www.esac.pt

Key words: *Zea mays* L., seedlings phenotyping, breeding, water stress, sustainable agriculture

Background

Maize (*Zea mays* L.) is one of the most important cereal crops worldwide. Due to the present climate change scenarios, selection for drought resistance is a major target in maize breeding. Breeding for drought resistance varieties is relevant to conventional, but especially to the less intensive farming systems, such as organic or low-input production. In these systems, the delivery of genotypes productive and resistant, adapted to stressed environments and grown under limited inputs' supply (e.g., water, fertilizers) is needed. Known both for their resilience and diversity, old varieties, landraces, and synthetic open-pollinated populations emerge as alternatives for maize improvement. In this context, improved phenotyping methodologies for selection of more drought-resistant genotypes, within these genetic materials, will contribute to a more economically and environmentally sustainable maize production. Simple, non-destructive and remote approaches to phenotype and select maize for higher drought resistance are thus required. Under the scope of the H2020 DIVERSIFOOD project, and starting from indoor semi-controlled conditions, our aim was to optimize screening procedures for maize seedlings grown under open field conditions. We tested a set of morpho-physiological parameters, based on thermography, leaf gas exchange and RGB imaging criteria, to select better growing and more productive maize genotypes within diverse populations. This multiple-criteria selection approach will help to develop more resilient populations, adapted to unfavourable growing conditions and to climate extremes.

Main chapter

Four Portuguese maize open-pollinated varieties were used in this work. 'Fandango' and 'Pigarro', two improved populations from the participatory maize breeding VASO program, were used both for the semi-controlled experiments (greenhouse) and field trials, and two farmers´ landraces, collected from contrasting altitudes associated with contrasting seasonal precipitation, were used on the field trials. Preliminary analysis took place under semi-controlled conditions, for the definition of the most interesting selection traits, which were later validated under open field conditions. On both experiments, for comparison purposes, the populations were subjected to two water regimes, continuous irrigation (control) and water withholding.

Under semi-controlled conditions, several biophysical and morpho-physiological parameters such as relative water content, photosynthetic pigments content, leaf temperature (Tleaf), individual leaf gas exchange, and plant growth were measured. Tleaf was assessed by thermography and leaf gas exchange was measured using an infrared gas analyzer.

Leaf gas exchange (stomatal conductance and net photosynthesis) was negatively influenced by drought only when the soil water content reached 15-10% of field capacity. In response to the applied water regime, significant variability was detected for the leaf gas exchange traits and infrared leaf temperature within the genotypes of a same maize population. On average, no differences were found for these parameters between the two populations (´Fandango´ and ´Pigarro´). Still, the variability detected for these parameters within the maize populations suggested that some individuals perform better under water-deficit conditions and that the tested discriminating parameters have potential as selection criteria tools, being considered for further validation under open field conditions. Field trials consisted of a RCBD, with 4 maize populations, with 3 repetitions, in control and water-holding conditions. Besides Tleaf and leaf gas exchange other expedite measurements, such as chlorophyll fluorescence (with a portable PAM) and visible RGB imaging (to follow the stay-green trait), are being taken along the maize life cycle.

Data will be analysed to identify the most interesting populations and/or outstanding individual genotypes within populations, considering also the stress recovery response to improve the drought resistance of these populations.

Session 3

New approaches of plant breeding for diversified and sustainable farming systems

Keynote

Participatory crop improvement for local / regional adaptation and produces

Isabelle Goldringer[1] and DIVERSIFOOD WP3 partners

[1] INRA, UMR 0320 Génétique Quantitative et Évolution - Le Moulon, 91190 Gif-sur-Yvette, France, isabelle.goldringer@inra.fr

Key words: participatory plant breeding (PPB), crop diversity, decentralized selection, methods and tools, new populations.

Background

Crop diversity is required to support more resilient and sustainable agricultural practices and diversified food systems. Developing Participatory Plant Breeding (PPB) approaches together with farmers is a good way to increase diversity in the fields and plates. To carry out on-farm PPB, farmers use and develop various types of varieties, according to their breeding objectives and the crop mating system. Usually they aim at developing varieties with a certain level of diversity, i.e. population-varieties, which are suited to their specific environmental conditions, farming practices and marketing objectives. For that, it is first needed to identify and characterize as much as possible diverse and untapped genetic resources, to combine them through the establishment of new populations and to improve those populations by different breeding methods. This process requires particular methods specifically adapted to on farm experiments and breeding (i.e. numerous, small, unreplicated / unbalanced trials...) and user friendly tools that would be available to the participatory breeding groups. All methodological aspects (organization, participation, trials, statistical analyses, quality tests, selection...) need to be specifically designed to fit each crop species and to be adapted to decentralized selection and to the context of the stakeholders involved (farmers, breeders, processors, consumers...). Here, we present the achievements in (i) the creation of new populations, (ii) the development of methods and (iii) the implementation of PPB programmes on a range of very important crops and vegetables in Europe such as bread and durum wheat, maize, tomato and broccoli, buckwheat, barley, lupin, carrots, onions, faba beans in DIVERSIFOOD WP3.

Main chapter

** Assessing the potential of the diverse methods for creating relevant diversity for PPB*

First, the breeding and management practices used for the development of the populations were described and their potential to create relevant diversity for PPB was analysed.

Pure lines, old varieties, landraces (Figure 1) may be used as a source of diversity. An example in Tomato was investigated in DIVERSIFOOD WP3 by ITAB and RSP. The pure lines, old varieties and landraces may be mixed and multiplied over generation to form dynamic populations (Figure 1) such as in the case of bread wheat managed by INRA and ITAB. They also may be crossed to create simple bi-parental segregating populations or more complex Composite Cross Populations based on multiple parents crossing (Figure 1). The effect of the origin and type of parents in bread wheat bi-parental crosses was studied by INRA and RSP, while FiBL investigated the creation of lupin CCP, RSR analysed bread broad based wheat CCP and INRA and ITAB compared dynamic populations and CCP of bread wheat.

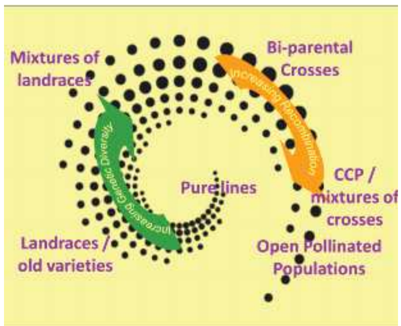

Figure 1: Scheme of the different types of population genetic structure ranged according to their increasing level of diversity and recombination.

Finally, in outcrossing species, mixing several varieties or landraces may lead to open pollinated populations (Figure 1) and the methods to design synthetic populations based on molecular data were investigated in maize by NOVA.

** Smart methods for decentralized on-farm breeding*

Participatory Plant Breeding (PPB) is based on decentralized on-farm breeding, which requires appropriate experimental methods. A decision tree (Figure 2) has been developed within DIVERSIFOOD, to match experimental design and statistical methods to a particular PPB project, according to its objectives and experimental constraints. Most of the methods have been implemented in an R Package: PPBStats (developed in DIVERSIFOOD deliverable D3.2 and described in D3.1), whose code is hosted on:

https://github.com/priviere/PPBstats. The decision tree is organised according to the objectives of the experiments. For each, there are several methods based on different experimental designs that require specific conditions (e.g. number of plots per location; of replicated germplasms within and between locations).

Data analysis from PPB programmes may have one or several of the following objectives. The first step is to identify the objective(s) of the PPB experiment:

- Improve the prediction of a target variable for selection by analyzing agronomic and nutritional traits.

- Compare different varieties or populations (hereafter called germplasms) evaluated for selection in different locations by analysing agronomic/nutritional traits and by sensory analysis.

- Study the response of germplasms under selection over several environments by analysing agronomic traits.

- Study diversity structure and identify parents to cross based on either good complementarity or similarity for some traits by analysing agronomic traits and molecular data.

- Study networks of seed circulation by analysing network topology.

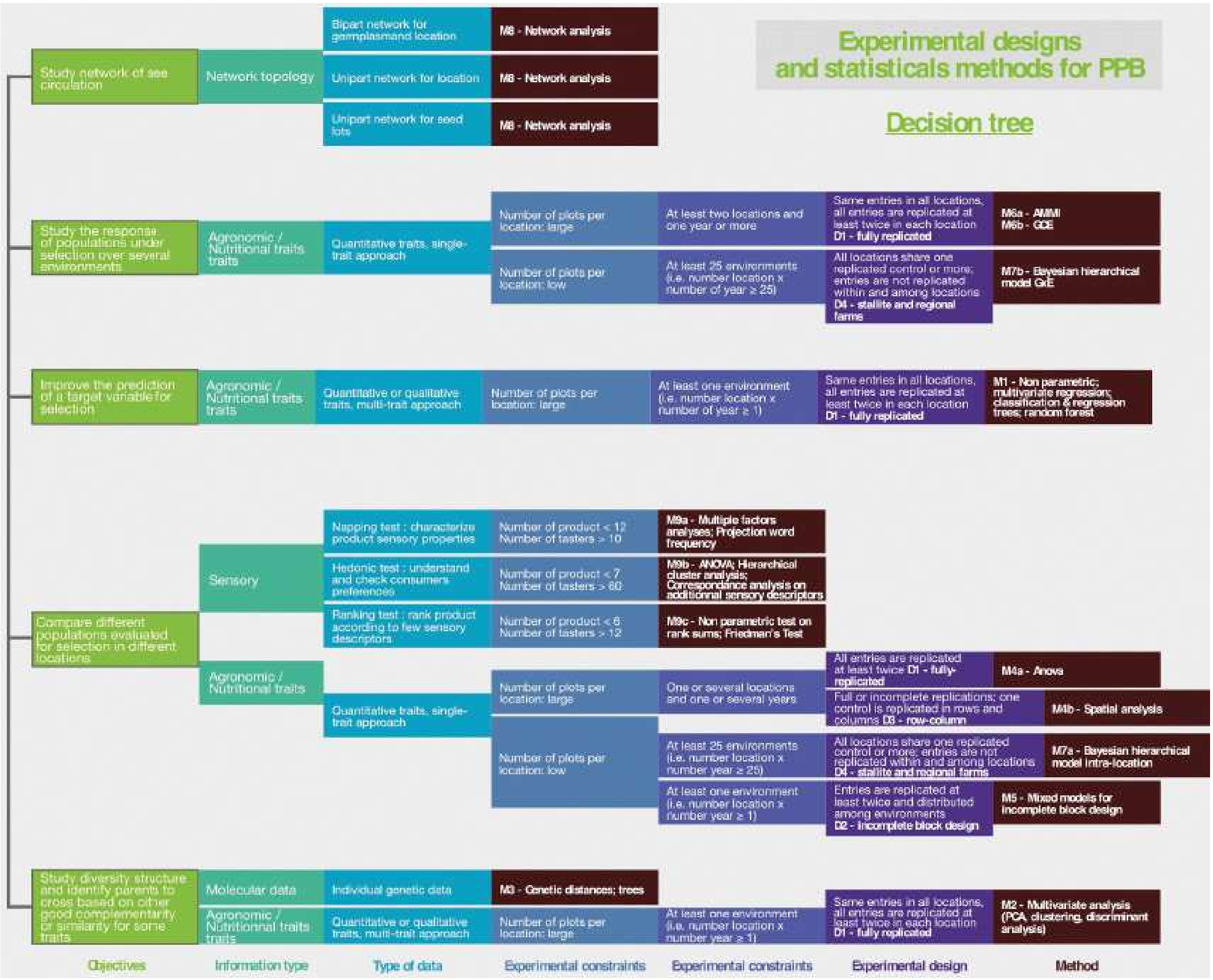

Figure 2: Decision tree to select experimental and statistical methods according to the objectives and the constraints of the PPB project.

The methods can be applied on four types of information: agronomic/nutritional data, sensory data, network topology of the seed circulation and molecular data. Four experimental designs can be used (in purple on the decision tree, Figure 2): D1: fully-repicated block design; D2: incomplete block design; D3: row-colum design; D4: satellite-farms & regional-farms. Nine statistical methods (in brown on the decision tree, Figure 2) can be used, depending on the design, the type of data and the objectives: M1: Non parametric methods; M2: Multivariate analyses (PCA); M3: Genetic distances & trees; M4a: Anova; M4b: Spatial analysis; M5: Mixed models for incomplete block designs; M6: AMMI and GGE; M7a: Bayesian hierarchical model intra-location; M7b: Bayesian hierarchical model GxE; M8: Network analysis; M9a: Napping tests; M9b: Hedonic tests; M9c: Ranking tests.

** PPB strategies for a diversified agriculture*

Within DIVERSIFOOD WP3, a panoply of breeding strategies inspired from previous projects was applied to a broad range of crops and in very diverse contexts. The methods tested have been specifically designed to fit each crop species and to be adapted to decentralized selection and to the context of the stakeholders involved (farmers, breeders, processors, consumers...). Multi-actors meeting have been organized to make demands and needs for the research emerge.

A few examples of the PPB programmes developed within DIVERSIFOOD WP3 are reviewed below. In bread wheat, different methods to design and select within mixtures of populations have been investigated by INRA and RSP. Mixtures appeared to be more productive and stable than their components. While selecting spikes within mixtures led to a larger response for some yield component traits, selection traits within components before mixing allowed to better preserve the initial diversity. Overall, the wheat PPB project conducted in France by INRA and RSP allowed to produce very interesting new population-varieties considering both agronomic traits and bread quality. Selecting different traits (plant height, grain size, disease resistance) and under different growing conditions (plant density, deep vs normal sowing) was investigating in wheat PPB in the Netherland by LBI. The first results show a significant response only for seed size selection. In Portugal, IPC and NOVA identified the best groups of maize populations to work on the basis of agronomic and organoleptic data. In Austria, Arche Noah focused the PPB activity on supporting networking and cooperation between different stakeholders (farmers, consumers, retailers, chefs, scientists). A participatory process was designed to define breeding strategies. Collective breeding activities, especially participatory assessment of quality traits have been conducted. In particular, the potential of farmer led selection for partial leaf mould resistance on tomato was investigating using decentralized on-farm breeding on 1-2 farms (Figure 3b).

Stakeholders meetings have been identified to be key steps for designing experiments and discussing results with farmers, processors, breeders and consumers / citizens (Figure 3a).

Figure 3: a) Stakeholders meeting in Portugal in maize PPB project. b) Tomato participatory selection in Austria.

Conclusion

Many other PPB programmes have been conducted on a wide range of crop species in DIVERSIFOOD WP3. While some positive responses have been obtained for some traits in some cases, difficulties have appeared in other cases. Based on experience, we found that the participatory process is the guarantee of the construction of designs and methods more appropriate to the local context and to reach the objectives set by the partners.

Oral

Evolutionary-Participatory Breeding of bread wheat for organic farming in Italy

Matteo Petitti, Riccardo Bocci, Bettina Bussi and Salvatore Ceccarelli[1]

[1]Rete Semi Rurali, Via di Casignano, 25, 50018 Scandicci (FI), Italy, www.semirurali.net, info@semirurali.net

Key words: Evolutionary populations, organic farming, bread wheat, climate change

Background

Crop varieties specifically bred for organic agriculture are lacking, imposing limits on the uptake and efficiency of organic production systems (Wolfe et al. 2008). The ability of Evolutionary Populations (EP) of crops to evolve and adapt to different agro-ecological environments makes them ideally suited to obtaining specifically adapted plants, allowing farmers to better harness the full potential of organically managed and marginal lands.

Main chapter

The same bread wheat EP (Ceccarelli et al. 2010) evolved for seven growing seasons (2011-2017) at sites in Tuscany (To) and Sicily (Si), resulting in two EPs, SOL_FL and SOL_LR respectively. The EP evolving in Sicily was moved to Abruzzo after three years, where it was called SOL_RO. From year five (2015) we conducted comparative trials for three years in each of the two main regions of adaptation (To, Si), and at two further locations in Molise (Mo) and Piedmont (Pi). In addition to the three EPs, the trials included a farmer's positive selection within SOL_FL named SOL_FLS, three other EPs obtained in the UK, three variety mixtures, three local varieties and one modern variety developed for low-input and draught tolerance as control. Field trials followed a row-column design in two replications with optimized randomization. A spatial analysis, adapted from Singh (2003), was run to generate Best Linear Unbiased Estimates (BLUEs). Genotype x Environment and Genotype x Trait Interactions were then derived using GGEbiplot in R.

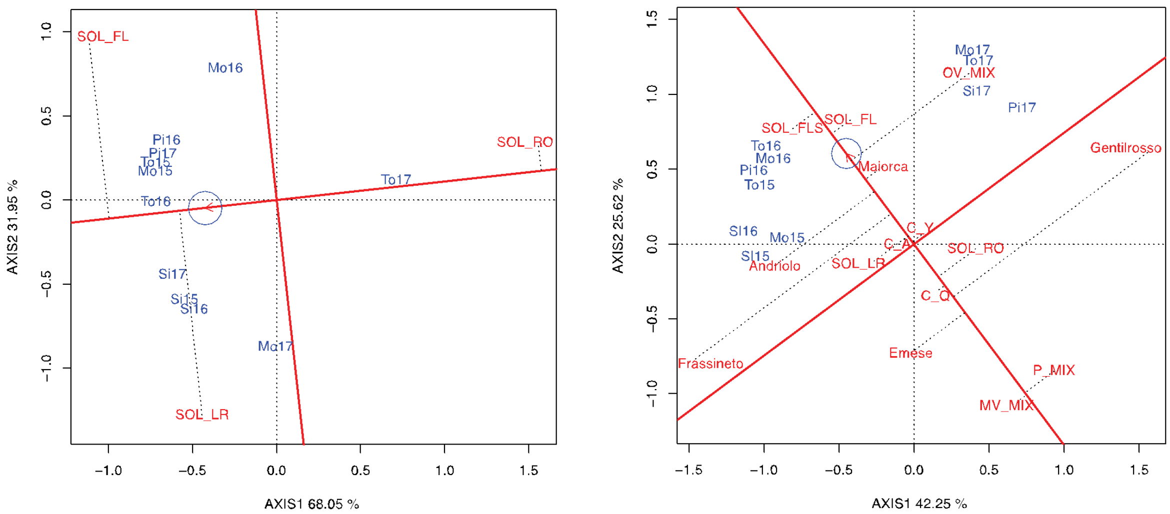

Figure 1: **Left:** The three SOLIBAM EPs generated by years of natural selection (SOL_FL, SOL_LR, SOL_RO) were specifically adapted to the regions where they evolved. This was accompanied, by a high level of yield stability in the environment in which each population evolved, and by a high instability across environments. **Right:** More than 350 farmers evaluated the material being tested: the preference was for some of the highest yielding EPs and varieties, such as SOL_FLS, SOL_FL, Andriolo and Maiorca, but also for low yielding mixtures, such as the mixture of old varieties (OV_MIX), because they were very tall.

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Oral

Culinary Breeding: expanding participatory selection to chefs and kitchens

Julie Dawson[1], Lane Selman[2], Tim Wastell[2], Kitt Healy[1], Anna Allen[2]

[1] University of Wisconsin-Madison, Department of Horticulture, dawson.horticulture.wisc.edu, dawson@hort.wisc.edu

[2] Oregon State University, Culinary Breeding Network, www.culinarybreedingnetwork.com. laneselman@gmail.co

Key words: organic vegetables, participatory selection, culinary breeding, on-farm breeding

Background

In the last decade, the number of public sector programs, independent seed companies, and farmer-breeders developing varieties for organic systems in the US has increased dramatically, particularly for farmers selling produce directly to consumers. The most important trait for these farmers is flavour, and this has led to collaborative breeding efforts involving farmers, chefs and a wide range of plant breeders working on varieties for organic systems. Seed regulations in the US do not require registration, so varieties selected by farmers and chefs can quickly become available to others. Diversified organic vegetable farmers often do not want to produce their own seed, but do want to be involved in selection and wish to support plant breeders focusing on organic systems (Hubbard and Zystro 2016). Still, selection for flavour is challenging as it involves the evaluation of a complex trait on large populations, which is fatiguing for tasters and expensive with classic sensory evaluation protocols. We have used recent research on the development of rapid sensory evaluation methods (Frost et al 2015) to involve chefs and farmers in selecting for flavour. In 2012, the Culinary Breeding Network (CBN) was created in the Pacific Northwest with a goal to increase communication and create collaboration between plant breeders and stakeholders, to develop more relevant and desirable cultivars. CBN now includes ~500 farmers, chefs, processors, wholesale and retail buyers, culinary educators, nutritionists, and eaters. The Seed to Kitchen Collaborative (SKC) started in 2013 as a partnership between plant breeders, farmers and chefs in Madison, WI. It has expanded to 70 farmers in the upper Midwest, chefs in other cities and ~ 30 public, private, and farmer plant breeders.

Methods

We present two tools that have proven useful in simplifying the evaluation of culinary attributes for breeding. The first is a flavor wheel, which represents the range of possible flavors for a particular crop and can be used to rapidly describe the flavor of samples using consistent terminology. With the CBN, chefs worked with different squash cultivars to develop a lexicon of descriptive terminology, which was used to create a visual aid. The second technique is projective mapping, a similarity-based rapid sensory evaluation method (Frost et al., 2015). With the SKC, chefs participated in a projective mapping exercise to characterize tomato cultivars and breeding lines. The chefs independently tasted each sample, and placed them on the mapping sheet according to their perception of the flavour. The maps created by each chef were then combined into a consensus map (Dawson and Healy 2018).

For the CBN squash evaluations, chefs worked with a range of squash cultivars to develop a lexicon of descriptive terminology, which the CBN used to create a visual aid for descriptive evaluations of breeding lines and cultivars. The lexicon development included 37 participants at two tasting events and 10 squash varieties. Varieties were sampled raw and cooked. Participants were asked what each sample reminded them of for flavor, aroma, and texture. No prompts were provided; the chefs were allowed to generate their own vocabulary to describe each sample. For cooked samples, 829 flavor and 317 aroma descriptors were recorded including 255 unique descriptors for flavor and 125 unique descriptors for aroma. These descriptors were analyzed to determine ones that occurred three or more times, resulting in 66 descriptors for flavor and 27 for aroma. These were combined and grouped into major flavor categories to generate a flavor wheel that can be used in future tasting events to facilitate the rapid assessment of culinary quality.

For the SKC tomato evaluations, chefs participated in a projective mapping exercise. In projective mapping, important flavor elements are assigned to axes drawn on a large sheet of paper. Sweetness, for example may be on the x-axis, with high sweetness on the right and low sweetness on the left, and umami, or savory flavor, on the y-axis. In the SKC, varieties are all grown in a common certified organic research field. The summer field crew (10-15 people) evaluates the flavor of all varieties using 1-5 intensity rating scales for sweetness, acidity, bitterness, and umami. A principal component analysis (PCA) is then used to select varieties for the chef evaluation, and to calculate the placement of flavor axes for the chefs. The chefs independently taste each sample, and place the samples on the mapping sheet according to their perception of the flavour attributes. The maps created by each chef are then combined into a consensus map using Multiple Factor Analysis (Frost et al. 2015). Projective mapping provides both a description of each sample's flavor and a picture of how the different samples compare according to the attributes being evaluated.

Results

Chefs and farmers were enthusiastic about these methods, as they were frustrated with more standard ranking scales that tended to constrain their evaluations, and with open-ended evaluations that did not produce easily comparable results. Figure 1 presents the flavour wheel designed by chefs participating in a sensory exploration of winter squash with the Culinary Breeding Network. The visual allows chefs and other culinary professionals to quickly find the best descriptor for what they are experiencing and reduces the time commitment per sample. It also results in a more uniform use of descriptors, without being overly confining. Based on the methods developed by CBN, the SKC is developing flavour wheels for beets and tomatoes in 2018.

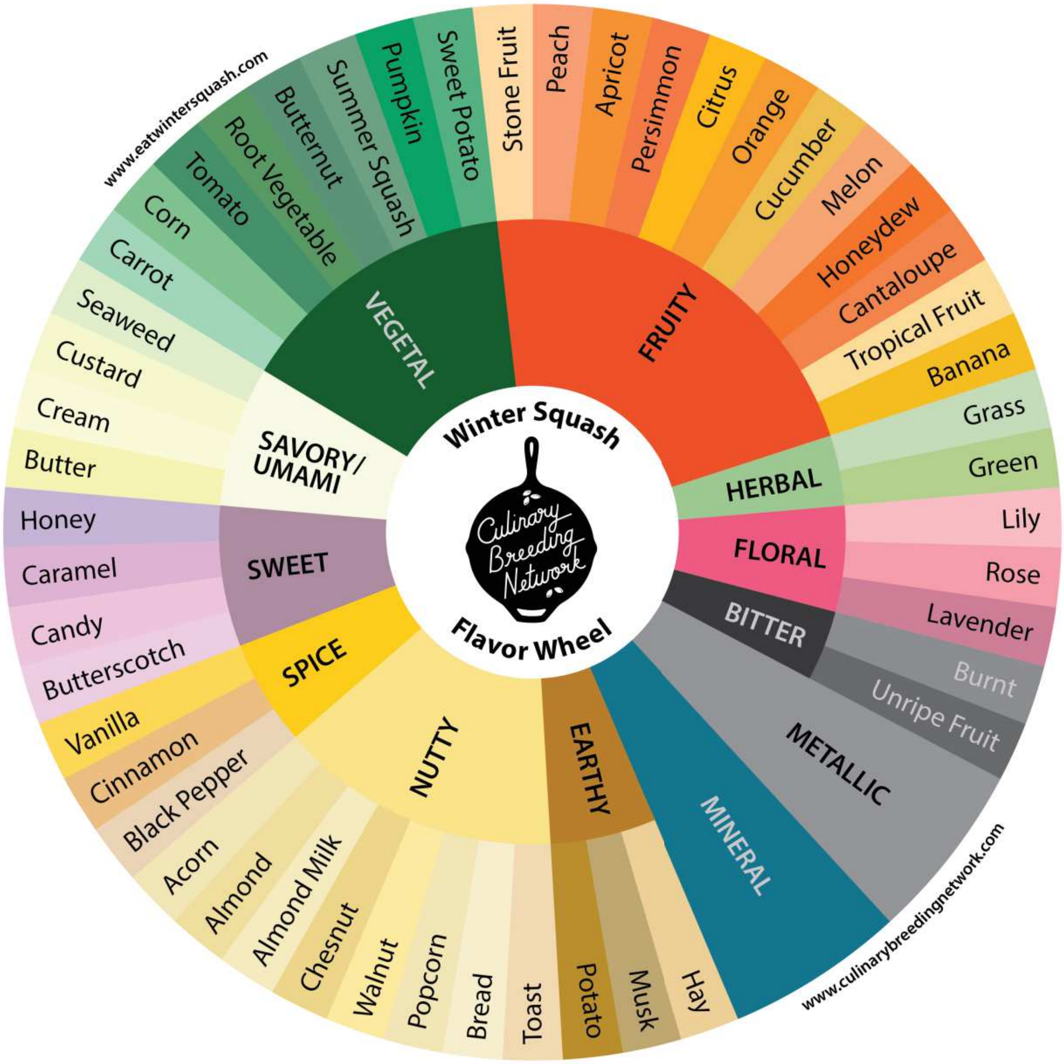

Figure 1. Visualization of sensory results. Flavour wheel designed by chefs participating in a sensory exploration of winter squash with the Culinary Breeding Network.

Figure 2 presents results from the SKC projective mapping of tomato samples. This method is extremely rapid for chefs to use and produces useful results for breeders. For example, from the results in Figure 2, we can see that the breeding lines P322-1-2-1, 45L23 and a new variety, Garden Gem are rated more highly for acidity, and that breeding line OSA404 is more sweet. The heirloom Pruden's Purple is the most highly rated for umami (savory) flavor. These results correspond to the ratings by the field crew for the individual flavor components, without requiring the chefs to rate each component for each variety. In addition to the projective mapping excercise, chefs are also asked to rate flavor intensity, the likelihood of purchasing that variety for their restaurant, and how easy they think the variety would be to prepare in their kitchen. Projective mapping has simplified the evaluation process for chefs as they are able to quickly compare samples, producing both quantitative and qualitative culinary quality evaluations of a larger number of samples than would be possible with individual descriptive characterization.

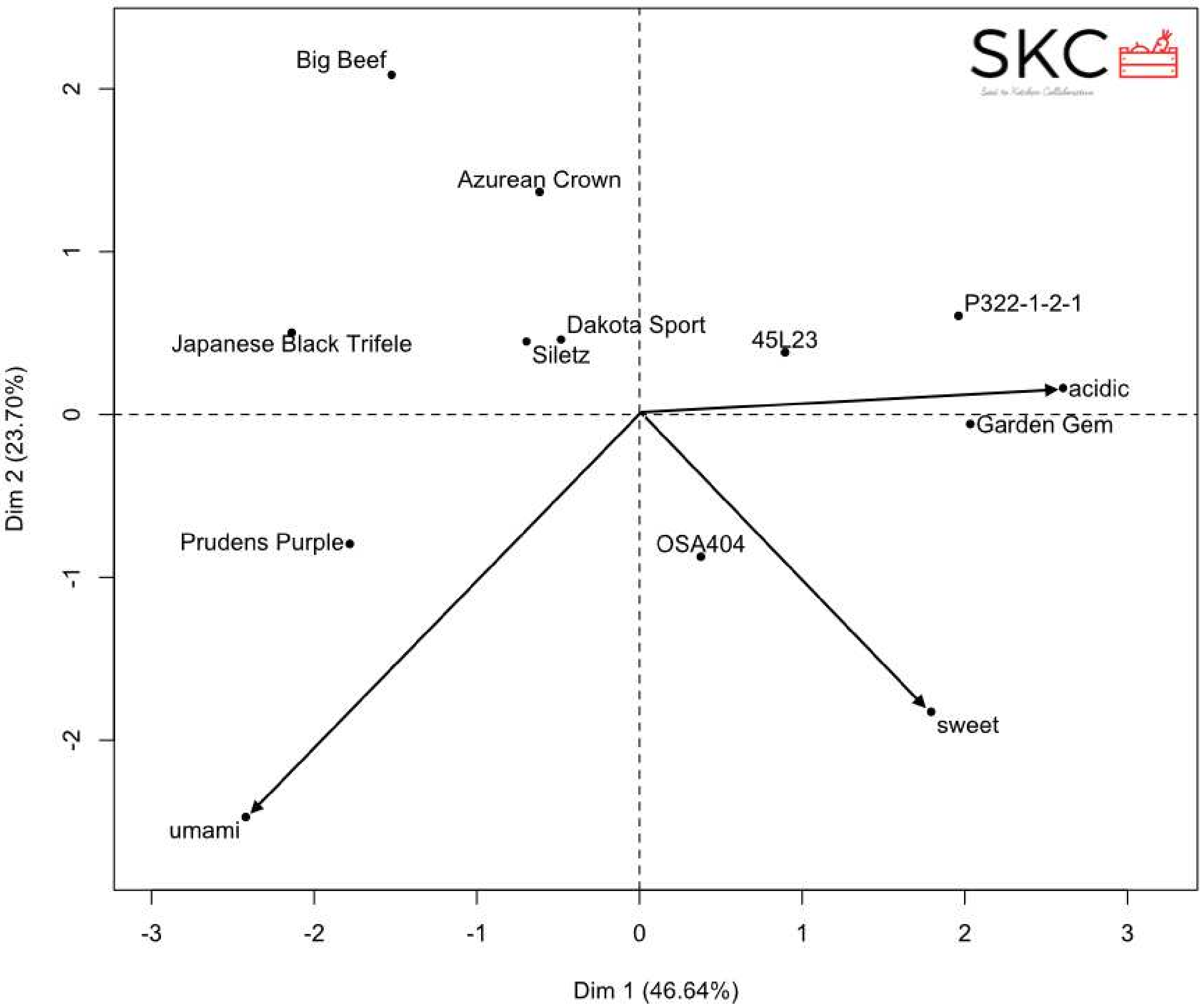

Figure 2. Visualization of sensory results. Consensus map developed with multiple factor analysis of chef sensory evaluation of tomato varieties and breeding lines with the Seed to Kitchen Collaborative.

Conclusions

Both methods proved intuitive and easy to use for chefs involved in the two projects. In addition, cross-project collaboration has increased and a national network is being piloted. We hope that the methods and resources developed will be useful for other breeding and trialling programs focused on flavour in vegetables.

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Poster in 3 min

Participatory on-farm breeding for diverse and adapted wheat mixtures

Gaëlle van Frank[1], *Pierre Rivière*[2], *Sophie Pin*[1], *Pauline Lhôte*[1], *Alexandre Duclouet*[1], *Olivier David*[3], *Yannick de Oliveira*[1], *Hervé Aribaud*[2], *Julien Bailly*[2], *Raphaël Baltassat*[2], *Lea Bernard*[2], *André Bochede*[2], *François Caizergue*[2], *Christian Dalmasso*[2], *Louisette Daubignard*[2], *Matthias Fattet*[2], *Jean-Sébastien Gascuel*[2], *Robin Gasnier*[2], *Ida Guignard*[2], *Christan Hardillier*[2], *Alexandre Hyacinthe*[2], *Sophie Leroy*[2], *Hélène Montaz*[2], *Adrien Pelletier*[2], *Olivier Ranke*[2], *Renaud de Rousiers*[2], *Marc Vanoverschelde*[2], *David Voireuchon*[2], *Sophie Woehling*[2], *Isabelle Goldringer*[1]

[1]UMR de Génétique Quantitative et Evolution - le Moulon, INRA – AgroParisTech – Univ. Paris-Sud – CNRS, Gif-sur-Yvette, France, www.moulon.inra.fr, gaelle.van-frank@inra.fr

[2] Réseau Semences Paysannes, France, www.semencespaysannes.org

[3] MaIAGE, INRA, Université Paris-Saclay, 78350 Jouy-en-Josas, France, www.jouy.inra.fr

Key words: Participatory Plant Breeding, Wheat, Mixtures

Background

Participatory plant breeding (PPB) is recognized as a way for farmers to obtain varieties better suited to their environments, practices and needs, especially in the context of organic or low-input conditions (Dawson *et al.* 2008). It allows to conserve and manage crop genetic diversity since a large number of often heterogeneous populations varieties is selected in different farms under contrasted conditions. Since 2006, researchers from INRA, farmers and facilitators of local farmers collectives from the Réseau Semences Paysannes (RSP) are working in collaboration in a wheat PPB project (Rivière *et al.* 2013). A common feature sought by farmers for their varieties is heterogeneity because it allows them a more stable and more resilient production, and mixing varieties or populations is a practice increasingly used by farmers. However, many questions remain as how to efficiently select for adapted mixtures. A three year experiment has been carried out by several farmers and the research team within the PPB project to study the impact of different management practices on the behavior of mixtures.

Main chapter

Two main hypotheses were considered: (i) mass selection within pure stand populations allows a positive response in subsequent generations so it might be efficient to select within components before mixing, (ii) we cannot predict the behavior of a plant in mixture from its behavior as pure stand since new interactions between plants from different populations appear and modify their phenotypes and performances, so it might be more efficient to select within mixture plants that behave well in interaction. Several practices were evaluated : (i) two years of mass selection within components before mixing, (ii) one year of mass selection within components, mixing those selections and then one year of mass selection within this new mixture, and (iii) two years of mass selection within the mixture. These practices were compared with the same mixture let to evolve without mass selection. Agronomic and morphological variables were measured on plants, spikes and grains.

First, the mixtures designed by the farmers were compared with their components. A positive mixing effect was found with most mixtures providing larger values than their components' means for many variables such as spike weight and length, and plant height. Then farmers' mass selection within components or within mixtures was assessed. In general, farmers selected mainly heavier spikes with more grains and in a lesser extent spikes with larger seeds. Selecting within mixtures gave larger responses but led to less diversified mixtures than mixing selections done within components. Overall, there was a significant added value of farmers' selection of mixtures compared to reproducing mixtures without selection. These results will contribute to improving methods and tools for on-farm PPB not only for this particular group of farmers but also for any farmers organizations who want to reintroduce within-field genetic diversity and become more autonomous in their agroecological systems.

Aknowledgments

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Poster in 3 min

Revisiting *Vicia faba* breeding criteria to include functional floral traits

María José Suso and Carmen Mateos

Institute for Sustainable Agriculture (CSIC), Spain, www.ias.csic.es, ge1susom@uco.es

Key words: Pollination environments – floral design and display - local adaptation - cropping system - breeding system

Background and Aims

Faba bean may facilitate the diversification on the agroecosystem both via growing faba bean in association with cereals and by enhancing associated diversity of wild fauna. The intercropping management might be useful encouraging good pollination and favoring the pollinator visits and consequently the insect-mediated outcrossing and thus to potentially increase seed production. Considering that open-pollination is a method of crossing well adapted to farmer management as well as to site-specific requirements, local bees could be managed in the farmer field with the aim of maintaining appropriate level of intra crop genetic diversity. When producing faba bean pollinator activity should be maximized. Flowers are the interface at which plants and pollinators interact, and their functional traits will influence how likely a pollinator is to visit the flower. In faba bean, with zygomorphic flowers, morphological modifications in the petals are thought to be associated with the visitation rate by pollinators. Simple morphological mismatches appearing in the flowers are an obvious problem. The manipulation of mechanisms that control functional floral traits for the benefit of pollinators has been suggested in the bid to increase yield and to improve populations (Suso et al. 2016) but little is known about floral trait expression in intercropping *vs* monoculture.

By quantifying and elucidating differences in functional floral traits of genepools and cropping and breeding systems, it could be possible to work towards breeding and growing genepools with pollinator-positive traits to both better understand traits underlying different ability of adaptation to local pollination environment and to support important ecosystem services.

Material & Methods

We create a bi-crop system, faba bean-spelt, to compare two cropping systems (intercropping *vs.* monoculture) and different faba bean genepools derived from two breeding approaches. Genepools highly homozygous and homogeneous, derived from selfing *vs.* highly heterozygous and heterogeneous, derived from open-pollination. We recorded, by using Digital Image Analysis, functional floral traits related to attraction, sexual dimension, and vector matching/pollen transfer efficiency. Our approach used ANOVAs and series of Pearson correlation coefficient's and PCAs to explore the phenotypic selection exerted by pollinators on floral traits involved in the plant pollinator interface. We examine whether variation in functional floral traits is associated with differences among cropping systems and breeding approaches.

Results

Attraction traits, related to the size of the flower, were clustered together and contributed to the maximum phenotypic variability. Likewise, vector matching traits were clustered together however its variability was lower. There were no significant differences in functional floral traits in their association among cropping systems or breeding approaches. However, genepools derived from the open-pollination approach, particularly under intercropping management, showed a general trend of greater attraction traits compared with the corresponding genepools derived from selfing approaches. The breeding approach apparently also modified some vector matching traits. The shape of the keel, presumably involved in the protection of the staminal column and thus contributing to pollen economy is affected by the cropping system. The cropping system influences functional floral traits but its effect is lower compared to the breeding approach.

The genetic background is manifested in terms of adaptation to the pollination environment. Our results are interpreted as a consequence of a previous adaptation to the different breeding approaches and include natural selection for the attraction to pollinator of the genetic material developed in open pollination environment and show that the transition from outcrossing to self-fertilization may be accompanied by the evolution towards plants with lower pollinator attraction and altered morphology. The data we report provide novel insight in strategies for breeding faba bean cultivars with enhanced both visitation rates and benefit for pollinators and for higher pollination efficiency and seed production.

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Poster in 3 min

Comparison of two strategies to increase intra-varietal diversity

Estelle Serpolay[1], Véronique Chable[2]

[1] ITAB (Institut Technique de l'Agriculture Biologique), France, itab.asso.fr, estelle.serpolay-besson@itab.asso.fr

[2] INRA de Rennes, France, www.rennes.inra.fr/sad-bcrp, veronique.chable@inra.fr

Key words: Intra-varietal diversity, CCP, dynamic population, soft wheat, buckwheat, farmers' selection

Background

The need for varieties adapted to Organic Agriculture have stimulated participatory breeding initiatives since the 2000s in France. Methodological issues emerged from the early experiences of farmer-breeders regarding methods of creation of intraspecific diversity for on-farm evolution, adaptation and breeding, as well as to achieve product quality. INRA/ITAB BCRP team has initiated 2 parallel long term experiments to explore those questions: one on bread wheat (Serpolay and Chable, 2015) and another on buckwheat. For each species, we have created 2 populations from the same parents: a dynamic mixture and a Composite Cross Population. Those 2 populations are multiplied and sometimes selected by farmers in different places over years and the evolution, impact of environment and farmers' selection is assessed on the performances of the populations, as well as on their diversity.

Material and methods

The objective of this work is to compare the 2 strategies of diversity creation for on-farm evolution and breeding for each species. The first strategy, the dynamic population (or dynamic mixture), consists of mixing parents and letting this mixture evolve over years. The CCP, in our case, consists in crossing parents 2 by 2 and mixing the progenies, and also letting it evolve over years. In both of them, the evolution will be observed with a particular focus on their adaptation to environmental conditions and their ability to answer to farmers' selection.

For soft wheat, crosses for CCP were realized in 2013 at INRA Rennes and INRA Le Moulon with 6 landraces, and the 2 populations were multiplied at one place the first year, and then on 2 farms (GS and FM) for 3 years. They were subject to natural selection only but it is planed that farmers select them from 2018 onwards. Field and spike observations were realized in 2017.

For buckwheat, crosses for CCP were realized in 2015 at INRA Rennes with 5 varieties (2 local landraces and 3 commercial varieties which are actually populations). Molecular analyses were conducted after the first year of multiplication and some observation on seeds were done throughout the years and in 2017.

Results 2017:

Soft wheat: Each type of population has its "own design" in terms of phenotypic traits distribution, which seems slightly affected by the place of cultivation. In terms of diversity, at GS, the CCP seems slightly more diverse than the Dynamic population, while the contrary seems to be true at FM. CCP global diversity level (Hs) seems more sensible to the environment (0.65 at GS and 0.6 at FM), instead the Dynamic population's diversity level seems stable across environments, even if the population is shaped slightly differently according to the specific environment. There is an interaction between the type of population and the environment as far as structuration of diversity is concerned.

Buckwheat: Our first phenotypical observations have revealed a major difference between CCP and dynamic populations for seed quality traits. Those of Petit Gris and Petit Prussien (small seed) seemed to be more expressed (more than 50%) than those of 'Billy' (large seed). Manual pollinations performed to create the CCP seem to have better distributed all the parents' diversity.

Conclusion

The 2 strategies will continue to be compared and submitted to farmers' selection in order to confront the interactions between and the impact of natural evolution and human breeding on diversity.

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Poster in 3 min

Development and characterization of barley populations for sustainable agriculture

Lorenzo Raggi[1], Salvatore Ceccarelli[2], Valeria Negri[1]

[1] Università degli Studi di Perugia, Dipartimento di Scienze Agrarie, Alimentari e Ambientali, Italy, http://dsa3.unipg.it, lorenzo.raggi@unipg.it , valeria.negri@unipg.it

[2] Rete Semi Rurali, Italy, https://www.semirurali.net, ceccarelli.salvatore83@gmail.com

Key words: *Hordeum vulgare* L., evolutionary breeding, parental contribution, yield stability, genetic diversity evolution, single nucleotide polymorphism

Background
A strategy to develop new varieties for organic (OA) and low-input (LI) agriculture is Evolutionary Breeding (EB) that relies in the combined effect of natural and human selection for the improvement of crop performances (Suneson 1956). The application of genomic analysis to populations selected through EB allows to shed light on the evolution of their genetic diversity across time and space (Thomas et al. 2015; Raggi et al. 2016) and the rapid identification of genotypes adapted to different environments dramatically increasing the possible applications of this breeding method.

Materials and Methods
An EB program was developed for the selection of barley (*Hordeum vulgare* L.) heterogeneous (populations) and homogeneous (pure lines) materials characterized by high yield and high yield stability under OA and LI. The program started with the selection of different Parental Populations (PPs) showing good agronomic performances under LI and high genetic diversity. The selected PPs were intercrossed to produce a Composite Cross Population (CCP, named AUT DBA) that was then multiplied for nine years under a LI without any artificial selection. The evolved CCP went through two cycles of artificial selection and a new population (named *mix48*) was built by mixing the seed of 48 lines characterized by high grain yield and highly diverse. Moreover, 13 highly productive pure lines were selected.

Yield and yield stability of the selected materials were evaluated in multi-environmental trials and in comparison to nine controls. The effect of (i) nine years of evolution on the CCP diversity and of (ii) three years of evolution of *mix48* population under contrasting environmental conditions were tested using different morpho-phenological as well as molecular markers and also in comparison with the original intercrossed PPs.

Results
AUT DBA, *mix48* and all the EBP lines (with the only exception of 07-SOL) significantly out-yielded some of the controls ($P \leq 0.05$). In low-productive environments the EBP populations and the EBP lines, yielded as well as the commercial varieties and significantly more than the average of the recently developed lines ($P \leq 0.05$). In addition, EBP populations and most of the EBP lines were more stable than the recently developed lines and the commercial varieties.

The mean values of the most common descriptors of genetic diversity were not significantly different between AUT DBA and the PPs. However, analysis of molecular variance showed some degree of differentiation between the two populations suggesting that evolution occurred during the nine years of multiplication. Differences among the *mix48* populations (the original and those multiplied in the different locations) were detected for all the morpho-phenological traits. The genomic analysis, carried out using 281 unique polymorphic SNPs on 444 also showed strong differences in the genetic constitution of the populations and that the PPs differently contribute to their genetic constitution.

Obtained results suggest that EB can be very useful to develop materials suitable for sustainable agriculture. A rapid response of the populations to climatic constrains was observed and different promising lines identified. These materials could be used in breeding for specific adaptation, to identify specific adaptive traits and key genomic regions involved in their control. This is particularly relevant under the current climate change scenario and for sustainable agriculture where farming conditions can be highly heterogeneous.

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Poster in 3 min

Efficient methods to develop new sweet corn cultivars for organic systems

Jared P. Zystro, William F. Tracy

Department of Agronomy, University of Wisconsin, United States, https://agronomy.wisc.edu, jared.zystro@wisc.edu

Key words: sweet corn, maize, organic plant breeding, experimental design, genomic selection

Background

Organic systems differ from their conventional counterparts in ways that may affect the relative performance of plant genotypes. If cases where rank-change genotype by system interactions are present, selection in organic environments may be most appropriate when developing cultivars for organic systems. However, doing so requires efficient approaches. Mating designs such as North Carolina Design II (NC DII) can allow the prediction of the performance of untested hybrids based on the evaluation of a subset of hybrids and inbreds. However, elite sweet corn varieties require superior performance in traits such as ear size with large dominance effects as well traits such as flavor with additive effects largely controlled by recessive alleles. Marker-based Best Linear Unbiased Prediction (GBLUP) incorporating both dominant and additive models may be superior to traditional NC DII analysis for predicting the performance of untested sweet corn hybrids.

Main chapter

The objective of this research was to determine the utility of using structured mating designs and genotypic information to select untested sweet corn hybrids for organic farming systems. Training trials of 100 sweet corn hybrids formed from four 5x5 NC DII mating blocks along with the 40 parental inbreds will carried out in 12 organic environments total over two years. Differences between the entries were seen for all measured traits, and differences in general combining ability (GCA) between inbreds wer seen for all traits except tenderness. The results of these trials were used to predict untested hybrids using both general combining ability (GCA) and GBLUP. Models incorporating dominance effects increased GBLUP cross-validation accuracy over models with only additive components. Validation trials across five environments were conducted to determine predictive accuracy of these systems. Both GCA and GBLUP based methods were relatively accurate for most traits, with little difference seen in the relative accuracy of the methods (Table 1).

Table1: Correlation between predicted and actual values of traits in sweet corn hybrid entries

Trait	GCA-based prediction	GBLUP- based prediction
Plant Height	0.82	0.93
Ear Height	0.77	0.92
Flavor	0.92	0.92
Ear Length	0.84	0.87
Ear Width	0.75	0.72
Husk	0.73	0.75
Tip Fill	0.36	0.38

Poster

Decision tools for improving underused Portuguese maize landraces

Mara Lisa Alves[1]*, Cláudia Brites*[2]*, Manuel Paulo*[2]*, Bruna Carbas*[3]*, Maria Belo*[1]*, Pedro Mendes-Moreira*[2]*, Carla Brites*[3]*, Maria do Rosário Bronze*[1,4,5]*, Jerko Gunjača*[6,7]*, Zlatko Šatović*[6,7]*, Maria Carlota Vaz Patto*[1]

[1] ITQB-NOVA, Portugal, www.itqb.unl.pt, mara@itqb.unl.pt
[2] IPC-ESAC, Portugal, www.esac.pt
[3] INIAV Oeiras, Portugal, http://www.iniav.pt
[4] Faculdade de Farmácia – Universidade de Lisboa, Portugal, www.ff.ul.pt
[5] IBET, http://www.ibet.pt, Portugal
[6] Faculty of Agriculture – Zagreb University, Croatia, http://www.agr.unizg.hr
[7] CoE CroP-BioDiv, Croatia, http://biodiv.iptpo.hr

Key words: open-pollinated varieties, *Zea mays* L., farmers, adaptability, quality, diversity

Background

There is an increasing awareness that preserving and promoting genetic diversity is crucial for the future breeding of food crops, such as maize, and therefore for promoting food security. Presently, in Portugal, one can still find maize landraces under cultivation. These have been used for centuries to produce the ethnic maize-based bread called "broa". By the time the European project DIVERSIFOOD started these materials were not subjected to any formal breeding activity, neither conventional nor participatory. Maize landraces, when compared to commercial hybrid varieties, are considered to have a broader plasticity to adapt to different environments. Given the present climate change scenarios, landraces could represent a valuable asset to breed for climate unpredictability. However, landraces are generally less productive than hybrid varieties. Therefore, their agronomic improvement (yield) is an important aspect that also needs to be taken into consideration in any breeding activities. In this work maize landraces, collected at farmers' fields from a region traditionally linked to the production of "broa" were evaluated from different perspectives (Alves et al. 2017). Our main objective was to generate decision tools to support an efficient and effective management and breeding of these underused genetic resources.

Main chapter

Sixteen farmers' maize landraces, together with 9 other maize open-pollinated populations breed by participatory approaches and chosen for comparison purposes, were evaluated for grain yield and ear weight in nine locations across Portugal. The different locations represent different areas where maize landraces are usually produced in Portugal, covering the different agronomic production systems normally associated with maize landraces. The maize populations' adaptability and stability were evaluated using additive main effects and multiplication interaction (AMMI) model analysis. These maize populations were also multiplied in a common-garden experiment for a comparative exploratory quality evaluation. Flour from each population was used to assess its chemical composition (protein, fibre, and fat), pasting behaviour, aroma volatiles and antioxidant compounds content (carotenoids, tocopherols, phenolic compounds). This phenotypic characterization was complemented with a molecular characterization, in which 30 individuals per population were genotyped with 20 microsatellite molecular markers.

Using diverse multivariate approaches we observed that the majority of the farmers' maize landraces had high levels of protein and fiber, low levels of carotenoids, volatile aldehydes, α- and δ-tocopherols, and low breakdown viscosity values. Regarding the agronomic performance, farmers' maize landraces had low but considerably stable grain yields across the tested environments. The integration of both phenotypic and genotypic characterization of these maize landraces allowed to identify possible future breeding paths. Therefore, through this work, valuable integrative decision tools were generated to support an efficient and effective management of these underused genetic resources.

Concluding, this work improved our knowledge on the agronomic and quality characterization of Portuguese maize landraces, and allowed us to postulate future paths for breeding using these materials.

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Poster

PPBstats: An R package for Participatory Plant Breeding statistical analyses

Pierre Rivière[1], Gaelle Van Frank[2], Olivier David[3], Camille Vindras[4], Salvatore Ceccarelli[5], Pedro Mendes Moreira[6], João Mendes Moreira[7], Mathieu Thomas[8,9], Isabelle Goldringer[2]

1 Réseau Semence Paysannes, France, www.semencespaysannes.org , pierre@semencespaysannes.org
2 UMR de Génétique Quantitative et Evolution - le Moulon, INRA – AgroParisTech – Univ. Paris-Sud – CNRS, Gif-sur-Yvette, France
3 MaIAGE, INRA, Université Paris-Saclay, 78350 Jouy-en-Josas, France
4 ITAB, Ferme Expérimentale - 2485 Route des Pécolets - 26800 Etoile sur Rhone, France
5 Rete Semi Rurali, Via di Casignano 25, 50018 Scandicci (FI), Italy
6 IPC -ESAC. Bencanta. 3045-601 Coimbra, Portugal
7 INESC TEC, Faculty of Engineering, University of Porto, Rua Dr. Roberto Frias s/n, 4200-465 Porto, Portugal
8 CIRAD, UMR AGAP, F-34398 Montpellier, France
9 AGAP, Univ Montpellier, CIRAD, INRA, Montpellier SupAgro, Montpellier, France

Key words: R package, Participatory Plant Breeding, statistical analysis

Background

Participatory Plant Breeding (PPB) is based on the decentralization of evaluation and selection in the fields of farmers and gardeners (Desclaux et al. 2008). All actors such as farmers, technicians, researchers, facilitators, consumers, etc. are involved in the decision-making process at all stages of the PPB programme. Such kind of involvement empowers all actors and responds to their needs (Sperling et al. 2001). During PPB programmes, experiments are carried out and different types of data are produced and must be analysed in order to support actors in their selection. These data covers the history of seed management (circulation, mixture, reproduction, selection, etc), agronomic trials, organoleptic tests and molecular data. Several programmes exist to analyze these different types of data but they are not always freely available and often scattered in different softwares.

Objectives of PPBstats

PPBstats is a freely available package based on the R software (R Core Team, 2017) that performs analyses on the data collected during PPB programs at four levels: network of seed management, agronomic trials, organoleptic tests and molecular analyses. The objectives of PPBstats are (i) to have a single package capable of performing all analyses required for PPB programmes with comprehensive documentation, and (ii) to create a community working on PPB programmes in order to improve the package, exchange on how to process data from PPB programmes and develop good practices. A website dedicated to PPBstats and a comprehensive tutorial to collaborate and use the package can be found at: https://priviere.github.io/PPBstats_web_site.

Examples of analysis performed by PPBstats

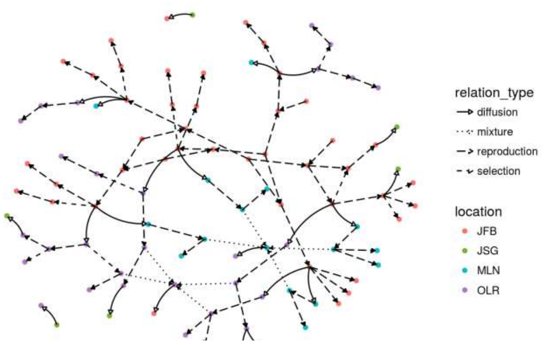

Figure 1. Network of seed management done with PPBstats

After a step of data formatting a workflow of analysis is carried out. For network analysis, only descriptive methods are provided, and graphical representations are available (Figure 1). For agronomic analyses, decision trees are available in order to perform the most appropriate analysis depending to the objective and the experimental constraints such as number of plots or seed available. Descriptive analyses such as barplot, radar, boxplot, interaction plot, maps can be done. Several models such as spatial analysis, mixed model, bayesian hierarchical models, AMMI and GGE are implemented. For organoleptic data, hedonic and napping analyses can be performed. For each model, a function checks if the model went well and mean comparisons as well as biplots can be visualized. For molecular data, only descriptive plots on the molecular marker data are implemented.

Contribute

Contributions to PPBstats are very welcome and can be made in four different ways: 1) testing the package and reporting bugs, 2) improving the code, 3) improving the documentation and 4) language translating. More information can be found on the website : https://priviere.github.io/PPBstats_web_site/contribute.html.

Acknowledgments
We thank Facundo Munoz for his help implementing S3 methods in the R code and Maria Carlota Vaz Patto for her advices regarding molecular analyses. This work has been first funded by the European Community's Seventh Framework Programme (FP7/9 2007–2013) under the grant agreement No 245058-Solibam (Strategies for Organic and Low-input Integrated Breeding and Management). It has been completed by funding from European Union's Horizon 2020 research and innovation programme under grant agreement No 633571 (DIVERSIFOOD project), by INRA (AgriBio4) and Fondation de France.

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Poster

Maize and beans Intercropping under Participatory Plant Breeding

Emanuel Amaral Ferreira[1], Pedro Mendes-Moreira[1]

[1]ESAC, Portugal, www.ipc.pt, pmm@esac.pt

Key words: Participatory Plant Breeding; Genotypes x Cropping system; Maize-beans intercropping.

Background

Maize and beans intercropping was very used in Portugal until the 80s. This system receives a renewed interest in organic and low input agriculture.

Plant breeding for intercropping consists in the co-selection of varieties of two or more species for a common output (e.g. yield, soil improvement)

The aim of this experiment was to compare the different genotypes across different cropping system for yield and selected agronomic traits of bush and climbing beans. Providing different solutions for farmers towards yield, yield stability and soil improvement.

Main chapter

The intercropping beans and maize trial was installed in the year of 2017 under organic farming at Coimbra, center of Portugal at ESAC.

Treatments included 9 beans entries both bush and climbing types with a maize landrace.

Phenotypic and agronomic traits were measured.

A randomized complete block design, with two replications was used. Each plot consisted of four rows (2, 04 m. long with 0, 75 m. between rows) for crops per se and two rows (2, 04 m. long with 0, 75 m. between rows) were used for the maize and beans in a row. Each plot was overplanted and harvested by hand.

The statistical analysis was done for the phenotypic, agronomic traits and seed characterization Land Equivalent Ratio (LER) was also calculated.

Differences in maize yield were observed across treatments.

The benefits of maize/beans intercrop related to seed yield for the use of farmers depend directly on the selection of cultivars in plant breeding programs.

Poster

Maize Germplasm Evaluation for Maize Bread. On-farm evaluation towards Transdisciplinary research.

Emanuel Amaral Ferreira[1], Duarte Pintado[1], Pedro Mendes-Moreira[1]

[1]IPC-ESAC, Portugal, www.ipc.pt, pmm@esac.pt

Key words: Maize populations; Participatory Plant Breeding; organic/ low input farming

Background

In 2010, 51 maize populations were evaluated under the SOLIBAM FP7 project, these populations included maize traditional and improved landraces, maize population hybrids, and synthetic populations. The DIVERSIFOOD H2020 project gave the opportunity to select and evaluate the most relevant entries promoting a higher participation of farmers, millers and bakers.

The aim of this work is to indicate the most appropriated germplasm for the maize bread under organic and low input agriculture conditions. This information will feed transdisciplinary research and its outputs will be needed to improve Participatory Plant Breeding goals.

Main chapter

Material & Methods

Nine entries were used and tested during three years. In 2015 at Lousada, in 2015 to 17 at Alvarenga and Vouzela from 2015 to 16. These locations are in the North and Central Portugal

For each location, a randomized complete block design, with two to three replications was used. Each plot consisted of two rows (6, 4 m. long with 0, 75 m. between rows). Each plot was overplanted by hand and thinned at seven leaf stage growth development stage.

Several traits were measured such as Plant height (H); Uniformity (U); Angle of the leaf (N); Tassel ramification (T); Ear height (E); Root lodging (R); Stalk lodging (S); cob weight per ear weight (CW/EW) and yield 15 % moisture (Yield15%).

To provide an overview of the data, means and coefficient of variation were used.

Results

The populations used indicate a broad differentiation across them (Table 1) and across environments.

Table 1. Evaluation of germplasm using h the respective means and coefficient of variation. of the teseer

	H		U		N		T		E		%R		%S		CW/EW		Yield15%	
Genotype	**Mean**	**CV**	**Meai**	**CV**	**Meai**	**CV**	**Mea**	**CV**	**Meai**	**CV**	**Meai**	**CV**	**Mean**	**CV**	**Mear**	**CV**	**Mear**	**CV**
Am (C3) 97	173,03	0,21	3,00	0,28	5,92	0,05	6,25	0,12	6,00	0,26	0,06	1,33	0,19	1,09	0,19	0,15	3,71	0,19
Broa 70	161,98	0,15	5,60	0,24	5,40	0,25	6,20	0,07	5,60	0,16	0,07	1,44	0,19	1,02	0,23	0,23	3,89	0,34
Broa 187	184,90	0,12	3,50	0,20	6,00	0,00	3,50	0,20	3,00	0,00	0,07	1,67	0,10	1,29	0,25	0,40	4,36	0,35
Pg C02014	238,22	0,11	3,67	0,31	5,92	0,20	6,75	0,17	6,67	0,15	0,10	0,99	0,20	1,25	0,33	0,22	5,50	0,34
Vermelhinho	213,89	0,13	3,11	0,30	5,44	0,16	6,56	0,13	5,78	0,14	0,06	1,33	0,04	1,14	0,16	0,52	5,54	0,35
Am C02014 Tomar	230,91	0,11	3,33	0,26	6,00	0,19	6,67	0,08	6,00	0,08	0,07	1,25	0,08	1,31	0,24	0,14	5,56	0,31
SinPre C02012 QC	216,38	0,13	3,15	0,46	5,46	0,19	6,31	0,16	5,54	0,20	0,12	1,04	0,13	0,78	0,25	0,11	6,52	0,23
Fn 2014	284,03	0,15	2,58	0,39	5,83	0,14	7,67	0,12	6,58	0,21	0,09	1,16	0,08	0,98	0,32	0,20	6,67	0,33
VA C1S1 2014	229,31	0,17	3,75	0,34	5,38	0,14	6,25	0,17	5,88	0,14	0,14	0,85	0,18	0,82	0,27	0,40	7,06	0,30

Conclusions

The results obtained will feed the transdisciplinary work to better define the most adequate germplasm per location and the correspondent PPB program

Heterogeneous wheat populations as a viable alternative to commercial varieties

Odette Denise Weedon[1], Jan Henrik Schmidt[1], Miriam Holtmann[1], Maria Renate Finckh[1]

[1] University of Kassel, Germany, www.uni-kassel.de/fb11agrar/fachgebiete-einrichtungen/oekologischer-pflanzenschutz, odetteweedon@uni-kassel.de

Key words: wheat, composite cross populations, yield and quality parameters, diseases, organic management.

Background

Composite cross populations (CCPs) are of great interest not only for their agronomic performance and yield stability, but also for selecting for improved wheat quality in organic systems while maintaining intraspecific genetic diversity for optimal resilience to biotic and abiotic stresses. However, heterogeneous populations face challenges with respect to variety registration, particularly according to the DUS criteria (distinctness, uniformity and stability) implemented for varietal and plant breeder protection through the UPOV agreement. However, under the Council Directive 2014/150/EU, heterogeneous populations of wheat, oats, maize and barley may be marketed until December 31st 2018. Since the implementation of the new legislation, a number of heterogeneous wheat populations have been registered and are available on the market. In order to investigate the potential of 10 CCPs of differing origins in comparison to five commercial reference varieties, a replicated two-year field experiment was established.

Materials and Methods

In 2005, the F_4 of three winter wheat composite cross populations (CCPs) based on 9 high yielding (OY), 12 baking quality (OQ) or all 20 parents (OYQ) from the UK arrived at University of Kassel, Germany, and since have been growing under both organic and conventional management with two parallel non-mixing populations of about 150m^2 each. In 2016/17 and 2017/18, the six CCPs (F_{16} and F_{17}) were compared to four commercial CCPs, two from Dottenfelder Hof (Germany) and two MAGIC populations from NIAB (UK). Five commercial pure line varieties were included as reference in the two-year experiment using a complete randomized block design with 3 replicates. Agronomic parameters such as grain yield, thousand grain weight and protein content, leaf and foot rot diseases and lodging were recorded. Data from the second experimental year will be available in late autumn and will be included in the poster.

Results and Discussion

Grain yields in 2016/17 ranged from 5.3 to 6.2t/ha (Figure 1), with only Achat, Capo, OYQII and NIAB Elite reaching yields above 6t/ha. Both OY CCPs and NIAB Diverse were particularly prone to lodging (>50% of the plot). Foliar disease incidence was low for all entries, while foot rot diseases were moderate with little difference found between wheat entries.

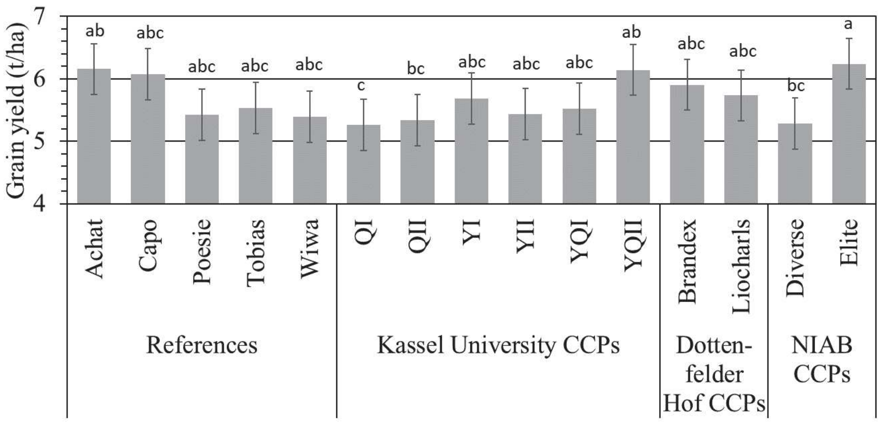

Figure 1. Mean grain yields and 95 % confidence intervals of 15 wheat entries (5 reference varieties and 10 composite cross populations of different origins) from the first experimental season (2016/17). Entries with identical letters are not significantly different (*P < 0.05*) according to least square means of a linear mixed model (Tukey adjusted *P*-values).

Overall, CCPs yielded similarly to the reference varieties, although the OY CCPs, particularly bred for yield, yielded lower than expected. Both OQ CCPs yielded poorly; however, higher grain protein content is expected to compensate for the lower yields. Generally, the heterogeneous wheat populations performed as well as currently grown pure line varieties, with some populations such as NIAB Elite, OYQII, Brandex and Liocharls indicating great potential as viable alternatives to a number of commercial varieties.

Poster

Influence of experimental design on on-farm evaluation of populations: a simulation approach

Gaëlle van Frank[1], Isabelle Goldringer[1], Pierre Rivière[2], Olivier David[3]

[1] UMR de Génétique Quantitative et Evolution - le Moulon, INRA – AgroParisTech – Univ. Paris-Sud – CNRS, Gif-sur-Yvette, France, www.moulon.inra.fr, gaelle.van-frank@inra.fr

[2] Réseau Semences Paysannes, France, www.semencespaysannes.org

[3] MaIAGE, INRA, Université Paris-Saclay, 78350 Jouy-en-Josas, France, www.jouy.inra.fr

Key words: Bayesian modelling, Experimental design, On-farm evaluation, Participatory Plant Breeding, Simulation

Background

Participatory Plant Breeding (PPB) has received much attention in recent decades for its ability to develop varieties adapted to the diversity of farms environments and to farmers' needs and practices (Dawson *et al.* 2008). Specific methodological issues arise when working with on-farm experiments, one being the implementation of an experimental design that matches farmers constraints and objectives, while allowing for accurate statistical analyses of the data. We took the example of a French PPB case on bread wheat, in which farmers, facilitators and researchers have co-constructed an experimental design that meets their needs, but is very unbalanced at both the farm and at the network of farms levels and required the development of Bayesian statistical models to compare populations on-farm, over the network and analyze their sensitivity to environments (Rivière 2013, 2015). Through a simulation study, we investigated the effects of different characteristics of the experimental design on the behavior of two of these Bayesian models to identify the range of values that are most appropriate and give recommendations for decentralized experiments in a large network of trials.

Main chapter

Material & Methods Datasets that differed by the values of the experimental design parameters (number of environments (farms x years), number of controls, number of controls' replicates, number of non-replicated populations, ...) were simulated and analyzed using the two models. Data were simulated for two characters that presented contrasted means and variances in real datasets from our PPB project: thousand kernel weight and spike weight. Then indicators of the adjustment and the precision of estimates were estimated. A sensitivity analysis was conducted to assess the impacts of each design parameter on these indicators.

Results The models estimated within-farm population effects well even with few replicated controls, and design parameters had small influence on the adjustment of these estimates to simulated data. However, replicating populations of interest within farms provided more power to detect significant differences as it improved estimates' precision. As expected, genotype effects and sensitivities over environments were mainly impacted by the number of replications of populations across the network. Effects of design parameters were mainly linear, except for the positive impacts of the number of environments on estimates of one of the models, which plateaued after 20 environments. These results can be used as a base for discussion with partners when setting-up on-farm experiments using these Bayesian models for the data analysis: if the aim is to compare populations on-farm we recommend that populations of interest be replicated within farms to have more power to detect differences, while if the aim is to characterize populations' behavior under various environmental conditions effort should be made to repeat populations in more environments.

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Poster

Introducing soybean as a diversification option to address food security

Jean-Claude N'Zi[1], Christophe Kouamé[2]

[1] World Agroforestry Centre (ICRAF) Côte d'Ivoire Country Program Cocody Mermoz, Abidjan, Côte d'Ivoire, www.worldagroforestry.org, j.nzi@cgiar.org University Félix Houphouët-Boigny, Abidjan, Côte d'Ivoire, UFR Biosciences, 22 BP 582 Abidjan, Côte d'Ivoire.

[2] World Agroforestry Centre (ICRAF) Côte d'Ivoire Country Program Cocody Mermoz, Abidjan, Côte d'Ivoire, www.worldagroforestry.org , Christophe.kouame@cgiar.org

Key words: *Glycine max* L, *Bradyrhizobium japonicum* agronomic performance, yield, variety, Côte d'Ivoire.

Background

The Nawa region contributes to 20% of cocoa (*Theobroma cacao* L.) production in Côte d'Ivoire. However, the development of cocoa-farming has been at the detriment of food crops. Most households are indeed in a situation of food insecurity and vulnerability with a prevalence of 21.5% and an acute malnutrition rate of 11.3% among cocoa producers in the region according to a recent survey. One of the recommended actions from the survey was to diversify agriculture with nutrients rich crops. Soybean (*Glycine max* L.) cropping system could go a long way to ensure food and nutritional security in the region. This crop can also use atmospheric nitrogen through biological fixation by establishing a symbiotic relationship with Rhizobium bacteria. This study was conducted to compare the agronomic performances of five varieties of soybean in Soubré and Logboayo and to evaluate the effect of IRAT-FA3 *Bradyrhizobium japonicum* strain inoculum on these performances.

Material and methods

A randomized complete block with a split plot with inoculation as the main factor and variety of soybean as subplot treatment replicated three times was used. Data were collected on nodulation and grain yield.

Results

High yield was recorded at Logboayo with 1838 kg ha^{-1} compared to 1220 kg ha^{-1} for Soubré. Variety V6_2013 with a yield of 1931 kg ha^{-1} and a good vegetative development could be recommended as elite variety for farmers. Variety V3_2013 showed ability to nodulation with indigenous rhizobia. Seeds inoculation resulted in an increase of nodules and growth of organs.

Conclusion

These results open option for soybean to be grown along other crops to address soil fertility problems in the project area, and this might be a good way to contribute to the diversification of cocoa production system to address the issues of food and nutrition security.

Poster

Component Analysis of Crop Yield links performance in the Isolation and Crop Environments

Dionysia A. Fasoula[1], *Vasilia A. Fasoula*[2]

[1] Agricultural Research Institute, Department of Plant Breeding, Cyprus, www.ari.gov.cy, dfasoula@ari.gov.cy

[2] University of Georgia, Plant Breeding, Genetics and Genomics Institute, USA, www.caes.uga.edu, vfasoula@uga.edu

Key words: prolificacy, density-neutral cultivars, prognostic breeding, organic agriculture, climate change

Background

Selection of superior plant genotypes practiced in the isolation environment, *i.e.,* in the absence of any interplant interference, has been demonstrated to be very efficient and capable of successfully discriminating among very similar plants with undetected differences when evaluated using conventional methods (Fasoula and Fasoula 1997a). However, sometimes there is scepticism by newcomers regarding the degree of correspondence of any identified superiority between the isolation and the crop environments. In other words, the argument goes, it may not be possible to select successfully in the isolation environment when the final conditions in the farmers' fields represent the crop environment, *i.e.,* dense stands. This presentation provides a brief summary of the research and the scientific findings underlying the link between performance in the isolation and crop environments. This link is the analysis of Crop Yield Potential into components that are precisely evaluated in the isolation environment and in the same generation of selection *vs*. the successive generations of the usual progeny testing (Fasoula 2013). A big novelty is that evaluation of Crop Yield Potential is approached by evaluating and predicting the crop yield potential of each individual plant through its siblings that are available in the current generation of selection, leading to increased efficiency.

Component Analysis of Crop Yield

Yan and Wallace (1995) distinguished two components of crop yield: (1) the yield per plant under very low crop density where there is no interplant interference within the crop stand, and (2) the tolerance to density that ties together the crop yield and the yield per plant. However, in their proposed equation, the first component requires quantification in the isolation environment, whereas the second component in the crop environment and in at least 3 different planting densities. Thus, the equation is not easily applicable and not at all so during the segregating generations, where each plant represents a distinct genotype with no replicate seed. Fasoula and Fasoula (2000, 2002) partitioned the crop yield potential of an entry (be it progeny lines, sibling lines, families, cultivars, *etc*.) into three components encompassing productivity, stability, and adaptability that are independent of each other and measured by simple phenotypic parameters in plants grown at ultrawide plant spacing excluding interplant interference (Fig. 1). Joint selection for the three genetic components leads to density-neutral cultivars, *i.e*., to cultivars that attain optimal yields over a wide range of plant densities. Important in this analysis is also that tolerance to density is not a component of crop yield potential, thus it is not necessary to work with different planting densities.

Prognostic equations for single plants and sibling lines, Figs 2 and 3 (Fasoula 2013; Fasoulas and Fasoula 1995)

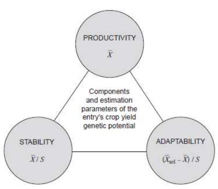

Fig. 1. Components of the crop yield potential

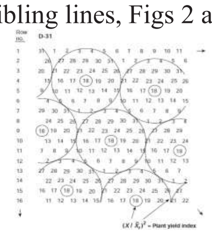

Fig. 2. Plant yield index

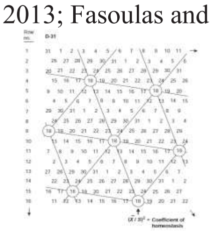

Fig. 3 Coefficient of homeostasis

Conclusions

It is possible to predict the crop performance of individual genotypes when they are evaluated in the isolation environment thanks to the novel partitioning of crop yield potential and the unique properties of the honeycomb selection designs. This partitioning is also the foundation of foreseeing and successfully realizing the creation of density-neutral cultivars with increased prolificacy, be it pure lines, hybrids, clones or populations. Density-neutral cultivars are especially important for farming under low-input and organic conditions and under climate change conditions.

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Poster

Climate resilient seed systems for evolutionary bread wheat populations in Italy

Matteo Petitti[1,2], Salvatore Ceccarelli, Riccardo Bocci[1], Charles Spillane[2], Peter McKeown[2], Bettina Bussi[1]

[1]Rete Semi Rurali, Via di Casignano, 25, 50018 Scandicci (FI), Italy, www.semirurali.net, info@semirurali.net
[2]MScCCAFS Program, Plant & AgriBiosciences Research Centre (PABC), Ryan Institute for Sustainable Development, National University of Ireland Galway, University Rd, Galway H91 REW4, Ireland, www.plantagbiosciences.org

Key words: Evolutionary populations, organic farming, bread wheat, climate change

Background

Evolutionary Populations (EP) of crops can adapt to climate change and different agro-ecological environments, increasing farmers' resilience and enhancing on-farm biodiversity. A precondition for the successful deployment of EPs is that the seeds is produced in the same region in which it will be utilized, with farmers playing central roles as both seed users and producers.

Main chapter

A bread wheat EP evolved for seven growing seasons (2011-2017) in an organic farm in Tuscany. In 2017 seed was distributed to 20 additional organic or low-input farms interested in growing the EP. The farmers belonging to this group, organised themselves as a network composed by seed-hubs and satellite farms according to location, size, availability of seed storage and access to seed cleaning equipment. Current and future climatic similarities between seed-hubs and the rest of the region were investigated using the Climate Analogues approach, whereby the climate of a chosen location is compared to that of a search range. The desktop Analogues R package developed at CIAT, Colombia (Ramírez-Villegas, et al. 2011) was used to obtain climate similarity rasters, which were rendered into maps using GIS software QGIS. There is evidence that specific adaptation of bread wheat populations can occur within a relatively short period of time, when these are grown within climatically homogeneous areas (Dawson, et al. 2012). We propose that the geo-climatic delineation of these micro-environments can be used to inform the establishment of decentralised EP seed networks, enhancing favourable Genotype X Environment Interactions in the short term, whilst offering a clear perspective on climatic trends over the longer term for the region.

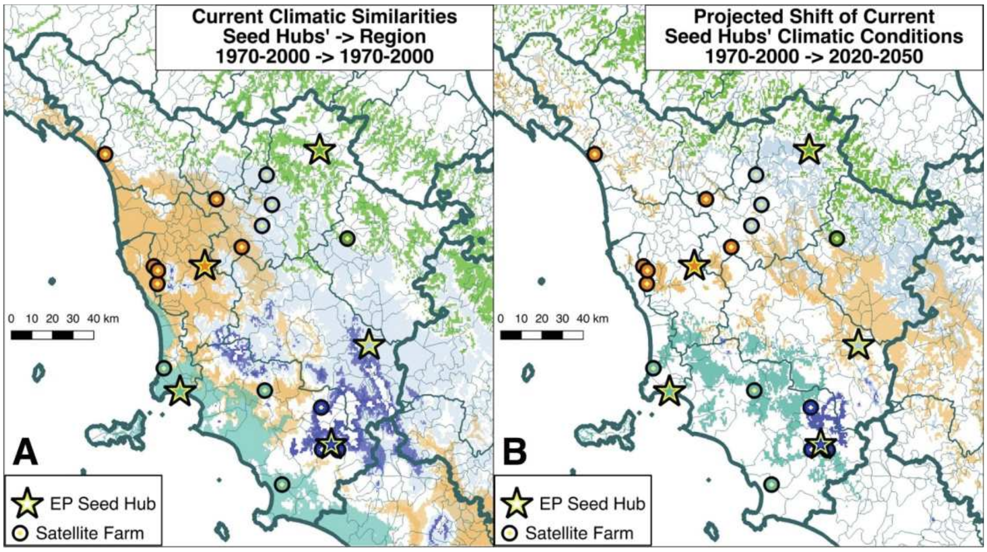

Figure 1. (A) Current climatic similarities between seed-hub centres and their surrounding area; and (B) Shift of these same areas by the 2030's under climate change RCP 8.5 emissions scenario. Season: Oct-Jun; Climate Similarity > 75%

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Session 4

From on farm conservation to Community biodiversity management

Keynote

Tools for community biodiversity management

Regine Andersen,[1] Béla Bartha,[2] Isabelle Goldringer[3], Mathieu Thomas[3,7], Kader Naino Jika[3], Emil Platzer , Beate Koller,[4] Pierre Rivière,[5] Riccardo Bocci[6]

[1] FNI, [2] Pro Specie Rara, [3] INRA, [4] Arche Noah, [5] Réseau Semences Paysannes, [6] Rete Semi Rurali, [7] CIRAD

Keywords: community biodiversity management, community seed banks, databases

Background

Community Biodiversity Management (CBM) focuses on empowering farming communities to manage their biological resources and the sustainable use of agrobiodiversity. The chief aim of CBM is described by de Boef et al. (2013) as the application of participatory processes to build community institutions and strengthen their capabilities for the conservation and sustainable use of Plant Genetic Resources, drawing on experiences from developing countries. However, the DIVERSIFOOD project has looked into applications of the CBM approach in Europe by examining initiatives undertaken by multi-actor networks working at local level as collective experiences of community biodiversity management. Our findings are based on a comprehensive Europe-wide questionnaire survey.

In the course of the project, we developed this diagram, showing the various activities included under the CBM framework and the factors that can affect them. All these activities are usually locally based and managed, and regulated by social norms that are shared and agreed on by the participants. In particular, DIVERSIFOOD devoted efforts to identifying and understanding community seed banks in Europe and the impact of social networks on biodiversity trends, and defining an enabling legal and policy environment for the development of CBM initiatives. This presentation summarises the results of these activities, which are also presented and described in detail in specific posters.

Figure 1 Community biodiversity management diagram developed by DIVERSIFOOD

Community seed banks

Community seed banks (CSBs) have been established since the mid-1970s in many parts of the world, with various forms and functions. The chief aims are to deal with the loss of agricultural genetic diversity and to enhance access to seeds adapted to local conditions, seeds not adequately provided on the market. Several case studies and analysis of CSBs worldwide have been published in recent years. Most of these studies focus on cases from developing countries, but little has been published on experiences from developed countries. CSBs in Europe are based on networks of seed savers and farmers. They may play a less decisive role for members of the respective community compared to CSBs in developing countries decisively contributing to food security.

However, also in Europe they play an important role in the conservation and sustainable use of plant genetic resources, especially where farmers and members of the public do not have easy access to public genebanks.

DIVERSIFOOD found that in Europe the number of CSBs has grown rapidly in the last 15 years. However, most initiatives do not use the term 'community seed banks': they identify themselves as networks, houses, libraries or archives for seeds and other plant-propagation material. This diversity in terminology reflects the general diversity within the CSB movement in Europe, also as regards age, size, goals, stakeholder groups, areas and activities, as well as governance structures. This can be explained by the fact that most CSBs in Europe have emerged locally from grassroot initiatives. Various role models – like older CSBs in Europe, seedsavers in the USA and Australia, or social movements in the Global South – have been adapted and developed by CSBs in line with local conditions. Roles and concepts of European CSBs can be roughly described by such keywords as 'diversity', 'conservation', 'exchange', 'community' and 'sovereignty', though their exact meaning has not been collectively defined and may differ from one initiative to another. CSBs in southern and western European countries tend to be initiated and run by farmers; in many northern and central European countries, private gardeners have played a central role. This, of course, is a gross simplification of a reality that is extremely diverse and dynamic. As regards goals and activities, many initiatives have seen a shift from mainly conservational approaches to more evolutionary ones – plant adaptation and participatory plant breeding are increasingly important in European CSBs. These initiatives work with a wide range of crops, managing on average several hundreds of accessions – genetic resources consisting mainly of local and farmers' varieties and earlier commercial varieties, as well as their own breeding material. CSBs in Europe see the impacts of their training and awareness-raising activities as their greatest achievements. Inadequate financial resources, leading to a shortage of manpower and technical equipment, as well as poor regulatory conditions, are the most frequently reported obstacles. Key strategies for overcoming these barriers include networking and cooperation within the CSB movement in Europe and around the world, mutual support and learning, and cooperation with other stakeholders who share similar goals and values. Further, the positive image and credibility that many initiatives have been able to build through their work represents an opportunity that can be used in public campaigns for better outreach and for improving the funding base. That being said, CSBs in Europe have not only succeeded in raising public awareness of the importance of plant and seed diversity, protecting local varieties and adapting them to current needs. Importantly, they have also enriched society with their innovations, including recently adapted tools and methods and social forms. They are helping to build a more sustainable food system and to make society more resilient and better prepared for the challenges we will continue to face, e.g. as regards climate change.

Databases

Databases are efficient tools for storing and managing CSB information. The DIVERSIFOOD project conducted a survey to ascertain how civil society organisations within DIVERSIFOOD manage their data. The questionnaire was sent to following partners: ProSpecieRara (PSR) in Switzerland, Réseau Semences Paysannes (RSP) in France, Rete Semi Rurali (RSR) in Italy, Red Andaluza de Semillas (RAS) in Spain and Arche Noah (AN) in Austria. Overall, the organisations work on cereals, forage crops (grasses), legumes, potatoes, beets (sugar, fodder), oilseed crops, fibre crops, vegetable crops, ornamental crops and trees. All these organisations have worked with local varieties and landraces or new farmers' varieties/populations. AN, PSR, RAS, RSP also work with commercial/registered varieties. All partners are working with varieties from the public domain. The organisations use databases with different objectives. All manage data on varieties in several locations over several years, and store information like agronomic data, organoleptic data, personal data on the farmers involved, country of origin, data on sources, date of entry of the accession, seed lots, plants within seed lots, photos, location of multiplication, field within location, history of seed lots within a network, climate where the accessions are grown, traditional knowledge linked to the varieties, traditional uses, local names, and more. These databases are often used in daily business activities. For AN and PSR, the database is the core of the functioning of the organisation. For RSR, RSP and RAS, the database is becoming increasingly important within the organisation. In all cases, databases are recognised as central to the functioning of these organisations. Each organisation has its own descriptors corresponding to local needs. Some of them are close to institutional standards. For example, AN uses EURISCO passport descriptors for all accessions, RSR uses Bioversity International descriptors, PSR has passport data for every variety. By contrast, RSP and RAS use none of these descriptors, but have elaborated their own descriptors. All the organisations have specific rules for data management. As for access to the data, there are two approaches: have the data open to everyone, or restrict the data to a group by requiring a password or similar. Regardless, several reports based on data are freely available. Data management gives rise to issues regarding interaction within the CSB and outside it. For RSP, RAS and RSR, questions concerning big data and data mining in CSB functioning are importance and are under debate. Regarding the outside world, there is a need for clarity regarding data collected and analyses through research programme as to property and access. Moreover, the political environment regarding patents on genes or just DNA sequences may pose a threat to biodiversity cultivation and use. There is a need for further legal work on data status and property in relation to the Nagoya Protocol and the International Treaty on Plant Genetic

Resources for Food and Agriculture (ITPGRFA), as well as financial support to maintain these organisations' databases and to ensure data quality.

Managing diversity within networks

Although several studies have shown that seed flows among actors (e.g. farmers, gardeners, maintainers) have a considerable impact on the evolution of crop genetic diversity, less is known about how seed circulation, farmers' practices and local selective pressures interact to shape diversity structure over time. Simulation-based approaches offer an attractive alternative to experimental studies and surveys that can be extremely costly and cumbersome to conduct, and to analytical approaches that are difficult to implement in such complex systems. DIVERSIFOOD has applied a simulation-based approach in numerically analysing the impact of seed circulation on crop biodiversity dynamics and exploring various scenarios of crop diversity management. To this end, we developed CropMetaPop, software that enables simulation of the genetic evolution of a crop metapopulation, including the various evolutionary forces (genetic drift, selection, mutation and migration) and demographic processes (extinction, colonization and population growth) that may be involved.

CropMetaPop was used within the framework of DIVERSIFOOD to explore the impact of (i) the organisational modes of different community seed systems (CSS), (ii) farmers' practices and (iii) environmental conditions for crop genetic diversity and population differentiation and adaptation. Four CSS – from Italy (RSR), Spain (RDS) and France (RSP and GDP) – contributed to this work. First, they described their collective organisational and farming practices. This information was converted into input parameters for the model and was employed to explore evolutionary scenarios for community seed systems and other modes of organisation. Relevant seed-circulation networks and evolutionary scenarios were co-designed with the partners in a participatory approach, and numerically assessed with the simulation model.

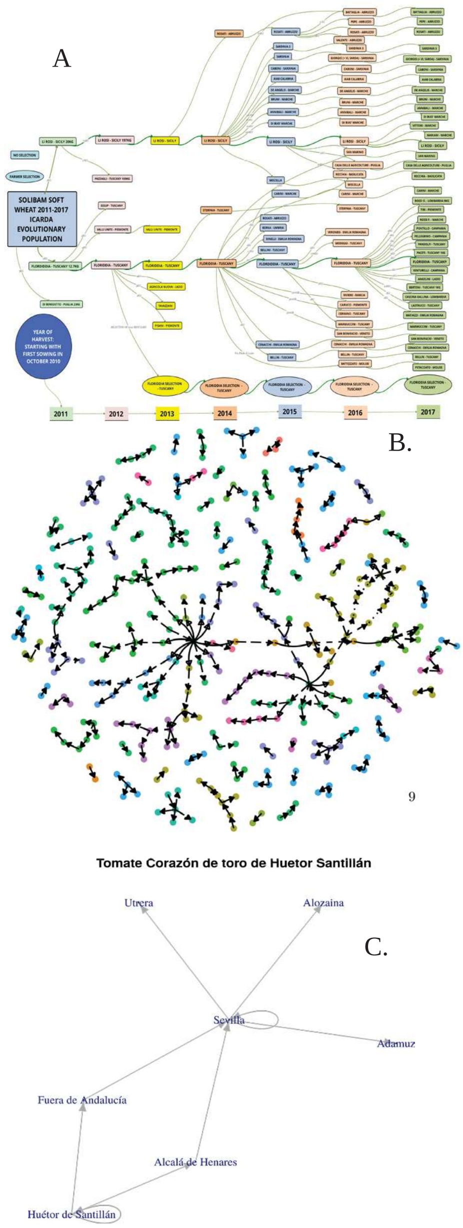

Figure 2 Examples of seed network modelling: A) bread wheat in Italy (RSR); B) bread wheat in France (RSP); tomato in Spain (RDS)

Farmers' rights

Article 9 of the International Treaty on Plant Genetic Resources for Food and Agriculture is devoted to Farmers' Rights. The Plant Treaty does not oblige countries to take any specific measures but leaves it to the national governments to define the content and realise these rights. Important elements mentioned include the protection of traditional knowledge; the right to equitable benefit sharing; and the right to participate in relevant decision making at the national level. Article 9 also addresses any rights that farmers have to save, use, exchange and sell farm-saved seed and propagules. The rapid development of community seed banks worldwide and related participatory initiatives are clear indications of a rapidly expanding movement for Community Biodiversity Management. In addition to directly contributing to the conservation and sustainable use of crop diversity (Andersen & Winge 2013, Andersen et al. 2018), this movement constitutes an important platform for the realization of Farmers' Rights.

Taking as our points of departure the results from the DIVERSIFOOD survey on community seed banks and our findings on enabling legal environments and previous research on Farmers' Rights, we have found that community seed banks and related CBM-initiatives can contribute to the realization of Farmers' Rights and provide an important platform for such realization.

Traditional knowledge is vital for understanding the properties of plants, their uses, cultural significance and how to grow them. The terms can also embrace preventing extinction as well as undue appropriation. Some CBM initiatives have provided platforms for sharing this knowledge and for establishing regulations to prevent misappropriation. Some have also deepened and expanded this traditional knowledge, and may be viewed as knowledge hubs in this regard.

The right to participate in benefit-sharing is central to achieving recognition of farmers' contributions to the global genetic pool, as well as stimulating and promoting further contributions. Highly successful forms of benefit-sharing have included the facilitated access to seeds and propagules for farmers and the sharing of knowledge and technology between breeders/scientists and farmers, as through participatory plant breeding. CBM initiatives provide platforms for a range of benefit-sharing approaches.

The right to participate in decisionmaking at the national level is important, to ensure that national policies are in line with the needs of the farmers engaged in agricultural biodiversity. There have not been many good examples here, but those involved in CBM initiatives are increasingly invited to participate in surveys and are consulted in hearings. This indicates potentials for CBM initiatives to serve as platforms for participation in decisionmaking at the national level.

'Any rights that farmers have to save, use, exchange and sell farm saved seed' is the vaguest provision in the Plant Treaty, but also the most important in terms of Farmers' Rights. If farmers are not allowed to continue with these practices, they will not be able to contribute to the global genetic pool. Legislation on intellectual property rights, variety release and seed distribution all erect barriers to these time-honoured practices. CBM initiatives provide a platform for advocacy as well as the development of systems of practices to save, use, exchange and sell farm saved seed that may circumvent the law.

Involving stakeholders

In many cases, legal barriers obstruct the development of CBM initiatives. Diverse legal issues have contributed as well. Examples include the lack of balance between seed legislation and the rights of farmers to save and exchange seeds, and the implementation of EU hygiene regulations that outlaw traditional products which have been produced and proven safe for centuries. Poor communication among stakeholders, lack of understanding of each other's motivations, and the heavy influence of industry on legislative processes are assumed to be main reasons for these regulatory gaps.

DIVERSIFOOD has developed and conducted multi-actor workshops to promote public dialogue on enabling legal environment for CBM initiatives. Six workshops were held in six EU member states between July 2016 to December 2017 with totally 277 participants from 25 countries. Officials and civil society representatives alike emphasised the exchange of experience among actors as advantageous. Practical projects and farmers' presentations were central in demonstrating the importance of an enabling legal environment. Needs for improvement were identified in the legal area of plant reproductive material legislation implemented in member states, especially concerning seed exchange, marketing of non-registered material and listing of varieties developed for growing under special conditions and conservation varieties (Commission Directives 2009/145/EC and 2008/62/EC). Regional multi-actor workshops can serve as an excellent tool for promoting biodiversity-friendly legislation and establishing a strong basis for institutionalisation of public dialogue. Indeed, in at least one country, the multi-actor workshop was followed by a process of adaptation of seed legislation.

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Oral

Realizing Farmers' Rights through community biodiversity management

Regine Andersen[1]

[1] Fridtjof Nansen Institute (FNI), Norway, www.fni.no, regine.andersen@fni.no .

Key words: seed sovereignty, enabling legal environments, Farmers' Rights

Background

Since the dawn of agriculture, farmers all over the world have sown, harvested and selected seed and planting material, actively exchanging these resources among each other. In so doing, they have developed an incredible abundance of crops, their knowledge and skills paving the way for the food plants that we use in agriculture and breeding today. This indispensable contribution has been largely unrewarded, and the global transformation of agricultural systems is increasingly threatening their important role. That is why an article of the International Treaty on Plant Genetic Resources for Food and Agriculture is devoted to Farmers' Rights (Art. 9). The Plant Treaty does not oblige countries to any specific measures but leaves it to national governments to define the contents and realize these rights. Important elements are proposed, i.e. (1) the protection of traditional knowledge; (2) the right to equitable benefit sharing; and (3) the right to participate in relevant decision making at the national level. It also addresses (4) any rights that farmers have to save, use, exchange and sell farm-saved seed and propagules. Implementation of Farmers' Rights has been slow, due to conflicts of interest between the seed industry and farmers engaged in biodiversity management (Andersen 2008).

The rapid development of community seed banks worldwide and related participatory initiatives, are expressions of a quickly expanding movement of community biodiversity management (CBM). While directly contributing to the conservation and sustainable use of crop diversity (Andersen and Winge 2013, Andersen et al. 2018), this movement constitutes an important platform for the realization of Farmers' Rights, as this presentation will show.

Main chapter

Taking the results from the DIVERSIFOOD survey on community seed banks, our findings on enabling legal environments and previous research on Farmers' Rights as points of departure, this presentation will provide an analysis of how community seed banks and related CBM-initiatives contribute to the realization of Farmers' Rights and provide a platform in this regard.

Traditional knowledge is vital for understanding the properties of plants, their uses, cultural significance and how to grow them. It can refer to preventing their extinction as well as their misappropriation. Some CBM initiatives have provided platforms for sharing this knowledge and for establishing the requirements for preventing misappropriation. Some have also deepened and expanded this traditional knowledge, and they may be viewed as knowledge hubs in this regard.

The right to participate in benefit-sharing is central to recognize farmers' contributions to the global genetic pool as well as to stimulate and promote their further contributions. The most successful forms of benefit-sharing so far comprise the facilitated access to seeds and propagules for farmers and the sharing of knowledge and technology between breeders/scientists and farmers, e.g. through participatory plant breeding. CBM initiatives provide platforms for various benefit-sharing approaches.

The right to participate in decision making at the national level is important to ensure that national policies are in line with the needs of the farmers engaged in agricultural biodiversity. There are not many good examples in this regard, but CBM initiatives are increasingly invited to participate in surveys and being consulted in hearings. This points to potentials for CBM initiatives to act as platforms for participation in decision making at the national level.

'Any rights that farmers have to save, use, exchange and sell farm saved seed' is the vaguest provision in the Plant Treaty, but at the same time the most important in terms of Farmers' Rights. If farmers are not allowed to continue with these practices, they will not be able to contribute to the global genetic pool. Legislation on intellectual property rights, variety release and seed distribution are among the laws that provide barriers to this practice. CBM initiatives provide a platform for advocacy as well as the development of systems of practices to save, use, exchange and sell farm saved seed that may circumvent the law.

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Oral

From variety selection practices to ecological justice

Hecquet Corentin[1], Stassart Pierre M. [1]

[1] Université de Liège – SEED, Belgium, www.seed.ulg.ac.be, corentin.hecquet@uliege.be

Key words: seeds, biodiversity, ecological justice, governance, lock-in, agroecology

Background and Main chapter

Via the « Distinction Uniformity Stability - DUS » criteria, the legislative framework of the European Union imposes a norm of standardisation for the registration of plant varieties in the catalogue allowing for the marketing of respective seeds. As practitionners of "crop biodiversity", very few farmers register their crop varieties, despite the existing derogation system. Starting from a set of four case studies – Semailles (Belgium), Kokopelli (France), Kaol Kozh (France) and Conaterra (Brazil)– we demonstrate that these crop diversity farmers develop numerous strategies to enable the circulation of their seed (sometimes kept invisible), but also, at the same time, to render visible their public demands (Dewey 1927). Behind these heterogenous strategies, we identify a common claim for ecological justice (Bosselmann 2008) which is composed of the right to existence, to recognition and to participation in the redefenition of the criteria for seed marketing, as well as the inclusion of the "non-human" in the debate.

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Poster in 3 min

Monitoring On-Farm Diversity in the United States

Cathleen Ann McCluskey[1]

[1] University of Wisconsin-Madison, United States, https://agroecology.wisc.edu/staff/mcclusky-cathleen
e-mail : cmccluskey@wisc.edu

Key words: on-farm diversity, farmer perceptions

Background

Seed is the foundation of agriculture and a resilient food system depends upon on a healthy and diverse seed system. Diversity in the field allows farmers to adapt to changing climates, pest and disease pressures, disruptions in the marketplace, and changes in resource availability. As the seed industry continues to consolidate and public plant breeding programs and research funding declines, it is important to consider implications of on-farm genetic diversity in the U.S.1 Who is monitoring and managing on-farm genetic diversity in the U.S.? Is it the farmers, universities, or seed companies?

Main chapter

Researchers are striving to track global trends in loss of crop species diversity in an effort to address concerns for the associated loss of ecological stability and implications for food security.2 Less research is focused on measuring on- farm genetic diversity. More specifically, there is little to no research published on an assessment of the genetic diversity found in U.S. fields today. A key question is how we define genetic diversity of cultivated crops at the farm- scape level and how we map that diversity to determine if it is agroecologically sound or too narrow. Once identified, what are the implications on the farm, to the larger seed system, and to society?

Corn serves as a model crop for consideration of trends in crop diversity as there are ~90 million acres (~36 million hectares) of field corn planted in the U.S. annually. This scale of production underscores our dependence on a single crop species and raises questions related to the genetic diversity of the corn landscape and more specifically the diversity of the varieties planted in farmers' fields.

My thesis research focuses on identifying the genetic diversity of U.S. standing field corn crop; analyzing if on-farm diversity is shrinking; and identifying the biological, economic, and social impacts genetic diversity of this crop has on U.S. farmers. Part of my research on this subject is considering the role farmers' play in impacting on-farm diversity through their seed choices. I am conducting a series of farmer interviews to better understand how U.S. farmers perceive and manage on-farm diversity including ten in-person interviews of Midwestnern corn growers. In this poster presentation I will present my research questions and initial findings focused on farmers' practices, strategies, and motivations for monitoring on-farm corn diversity.

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Poster in 3 min

A modeling approach for on farm crop diversity management

Abdel Kader Naino Jika[1], Mathieu Thomas[2,3], Matteo Petiti[4], Riccardo Bocci[4], Isabelle Goldringer[1]*

[1] INRA, UMR 0320 Génétique Quantitative et Évolution -Le Moulon, 91190 Gif-sur-Yvette, France
[2]CIRAD, UMR AGAP, F-34398 Montpellier, France
[3]AGAP, Univ Montpellier, CIRAD, INRA, Montpellier SupAgro, Montpellier, France.
[4]Rete Semi Rurali (RSR), Via di Casignano 25 Scandicci (FI) , ITALIA

Key words: social network, crop metapopulation, simulation model, community seed system (CSS), seed exchange

Background & objectives

Although several studies have shown that seed flows among actors (farmers, gardeners, maintainers...) strongly impact the evolution of crop genetic diversity, there is a lack of knowledge on how seed circulation, farmers' practices and local selective pressures interact together to shape diversity structure over time. Simulation-based approaches offer an attractive alternative to experimental studies and surveys that are very cumbersome and costly to conduct, and to analytical approaches that are difficult to implement in such complex systems.

The objective is to use a model-based approach in order to explore the impact of the organisation modes of different community seed systems (CSS), farmers practices and environmental conditions on crop genetic diversity and population adaptation. Here we present a case study of an italian CSS where we simulated the seed circulation system of a wheat population under different geographic distributions of environmental selective pressures and assessed the impact on the genetic diversity over 15 generations.

Main work

We used computer simulations to numerically assess the impact of different topologies for seed circulation networks in different contexts (farmers' practices and environmental conditions) on the dynamics of crop genetic diversity. In particular, we applied a participatory approach to co-design with a farmers' seed network involved in wheat diversity management in Italy (Rete Semi Rurali) realistic crop diversity management scenarios that can represent their current practices and possible changes that would allow to improve the management objectives. For that, we used CropMetapop, a previously developed software that allows to simulate the genetic evolution of a crop metapopulation, including the different evolutionary forces (genetic drift, selection, mutation and migration) and demographic processes (extinction, colonization and population growth). The originality of CropMetapop is to integrate seed circulation among actors (seed exchange) through dedicated migration and/or colonization of seed samples among populations.

We then used an iterative process where the functioning of the model and the results for simple cases were shown to and discussed with RSR members in order to further co-construct the current and alternative scenarios. The parameters used in the model attempt to represent RSR current management of a wheat population with high genetic diversity that was created in 2010. This population was initially distributed into two farms (Sicily and Tuscany) and then diffused to other farms, where they have been cultivated during several generations depending on the farm. The two initial farms correspond to contrasted environments with different temperatures and rainfall. Based on this information, we simulated a population with a high level of genetic diversity in which we sampled two populations representing the populations grown by RSR in Sicily and Tuscany. These populations were then gradually diffused into 51 Farms using a colonization rate of 0.2. The diffusion scheme was based on the real seed circulation network. Tree scenario were analysed: in the first one (fig 1) all populations have been grown in the same environment, in the second (fig 2), each initial population (populations from Sicily and Tuscany) gave seeds only to farms belonging to the same environment. In the third scenario (fig 3) we assumed an environmental gradient with localities at different latitudes having different environments. The first results were discussed with RSR to propose a more accurate representation of the evolutionary pressures that affect populations. The potential of such approach to identify the most influential parameters in crop genetic diversity management will be discussed.

Figure 1

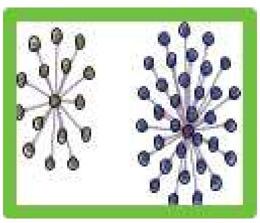

Figure 2

Figure 3

Acknowledgments : This work was supported by DIVERSIFOOD project (European Union's Horizon 2020 research and innovation programme).

Poster in 3 min

Management of plant health and crop diversity – a case study

Stephanie M. Klaedtke[1,2], François Mélard[1], Véronique Chable[2] et Pierre M. Stassart[1]

[1] SEED, Université de Liège, Av. Longwy 185, 6700 Arlon (Belgium), stephanie.klaedtke@uliege.be

[2] INRA BAGAP, 65 rue de St. Brieuc, CS 84215, 35042, Rennes (France)

Key words: Plant health, artisanal seed companies, socio-technical norm, attachment modes, professional identity, agroecology

Background

All over the globe, networks of seed growers are cultivating crop diversity in fields and gardens. Their contribution to the maintenance of this diversity has been studied, but research has widely left aside their management of plant health. The governance of bean health practiced by an association of artisanal seed companies is approached as a case study in the objective of specifying how management of crop diversity and governance of plant health are articulated.

Main chapter

Departing from tensions concerning the management of common bacterial blight, a seed-borne disease of common bean, we discuss two different and incompatible approaches to plant health management. On the one hand, the European Plant Health regulation, here considered as a socio-technical norm (Callon and Rip, 1992), prescribes the management of certain plant pathogens as "quarantine pests". Thereby, marketing seeds carrying the pathogens is prohibited in the aim of eradicating them on the European territory. On the other hand, the plant health management practiced by a group of organic and artisanal seed companies, *Croqueurs de Carottes*, aims at living with plant pathogens as part of the production system, considering plant diseases as part of what crops may express. In attempts to undermine the measures prescribed by the European Plant Health regulation and to make space for their own management practices, the seed artisans engage in the field of scientific knowledge and question the rules and procedures on which the regulation is based. At the same time, they question the socio-political stakes of the Plant Health regulation by redefining plant health, both in their discourse and through their management practices, which we here describe as *in situ* management of plant health. In this *in situ* management, the boundaries of cultivated plants and seeds are redrawn. Its practice links the governance of plant and seed health to the management of cultivated biodiversity. It requires considering plant health management at the level of the collective, including the producers and users of the seed. We conclude that the seed artisans concomitantly construct and defend their professional identity as they strive to obtain recognition for their modes of attachment (Latour, 2007) to plant diseases.

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Poster in 3 min

Conservation and usage of chestnut biodiversity: a case study of partnership research

Cathy Bouffartigue[a], Nathalie Couix[a], Timothée Flutre[b], Teresa Bareneche[c], Laurent Hazard[a]

[a] AGIR, Université de Toulouse, INRA, INPT, INP-EI PURPAN Castanet Tolosan, France, cathy.bouffartigue@inra.fr ; nathalie.couix@inra.fr ; laurent.hazard@inra.fr
[b] INRA, UMR Amélioration Génétique et Adaptation des Plantes méditérranéennes et tropicales, F-34060 Montpellier, France ; timothee.flutre@inra.fr
[c] UMR 1332 de Biologie du Fruit et Pathologie, INRA, Université de Bordeaux, F-33140, Villenave d'Ornon, France ; teresa.barreneche@inra.fr

Key words: Genetic resources, Cultivated biodiversity, Management practices, Partnership research, Chestnut

Background

The decline of agrobiodiversity and the need for its conservation are widely recognized (FAO, 1999). The management practices of agrobiodiversity, such as informal plant material and know-how exchanges, are likely to play a crucial role in its *in-situ* conservation (Calvet-Mir et al., 2012; Reyes-García et al., 2013). However, its determinants needs to be further studied to relate practices and their impacts on the dynamic of biodiversity. This is particularly true for underutilized crops in western countries, overlooked by research funding and whose cultivation fell into disuse.
In the case of perennial plants, the disuse over several decade lead to the loss of part of the genetic resources (GR) due to the death of the plants consequent to the abandonment of the crop and to the loss of associated knowledge.

Main chapter

This communication is a proposal based on an on-going PhD. The ambition is to consider together the social and biological aspects embedded in the GR of an underutilized fruit tree species. The morphological and genetic descriptions of local cultivated chestnut agrobiodiversity are both recorded, together with the practices and perceptions of conservation and management by local associations. The aim of this work is to answer the following question:
What are the influences of practices and views of farmer groups and civil society organizations on the dynamics of the genetic resources of an underutilized fruit tree species?
In order to set the context, the first section will present challenges on how to assess GR of an underutilized fruit tree species. In the second section, we will detail our strategy and our research device. In the last section, preliminary genetic results will be presented.

Map: Partners' associations for the genotyping of local chestnut landraces (blue stars are sampling sites and numbers in brackets correspond to sampled trees). Map source: CORINE Land Cover - France métropolitaine – 2012. © les contributeurs d'OpenStreetMap) :: Photo: Visit of an old chestnut stands with four partners' associations. Author: L. Hazard 2017

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Poster in 3 min

Mapping European CSAs' Practices for Cultivated Biodiversity

Jocelyn Parot[1], Cathy Bouffartigue[2], Adrien Alber[3]

[1] URGENCI, jocelyn.parot@urgenci.net

[2] AGIR, Université de Toulouse, INRA, INPT, INP-EI PURPAN Castanet Tolosan, France, cathy.bouffartigue@inra.fr

[3] adrien.alber@laposte.net

Key words: Community supported agriculture (CSA), cultivated biodiversity, best practices

Background

Ex-situ and in-situ management of biodiversity are complementary approaches (Brush, 1989) and there is an increasing recognition of the importance of developing a dynamic management of *in-situ* biodiversity (Hammer et al., 2003). The interest and specificities of *in-situ* biodiversity management in traditional agricultural systems, home gardens, seed saving and seed swapping systems are well studied (Jarvis et al., 2007; Osman and Chable, 2009; Reyes-García et al., 2013). Some studies suggest that food systems based on a close partnership between producers and consumers may also provide a strong support to *in-situ* biodiversity (Galt et al., 2012; Minvielle et al., 2011). Indeed, the Community-Supported Agriculture (CSA) movements set as an objective the reinforcement of plant and animal diversity. Nevertheless, at least to our knowledge, few studies have characterized the possible role of CSAs in the *in-situ* management of biodiversity. Are the close partnerships between farmers and consumers a source of social innovation for in-situ management of biodiversity?

Urgenci (the international network for Community-Supported Agriculture) is part of DYNAversity, a Horizon 2020 project which seeks to identify the actors involved in plant genetic conservation for agriculture, in order to shape new models of networks and to develop new schemes of governance. In this project, Urgenci seeks to identify "best practices" of in-situ management of plant biodiversity in CSAs and CSAs networks.

Main chapter

This study focuses on *in-situ* management of plant biodiversity practices developed in consumers-producers partnerships at the European level. The aims are to get an overview of the current practices and to identify some CSAs' specific *in-situ* biodiversity management practices. Thanks to Urgenci member organizations, semi-directed interviews were performed online, by telephone and face-to-face. With qualitative and quantitative questions, primary data has been collected both at the level of single CSA groups and at the level of CSA networks: general infos on the CSA, species concerned (vegetable, grains, legumes, etc.), practices of in situ management (cultivation/conservation/breeding strategies) roles of consumers and producers in the *in-situ* management of biodiversity (type of partnership, instigator of the initiative), anteriority of the initiative and social dynamics, limits and challenges encountered. The diversity of practices will be explored thanks to descriptive statistics and typology. Then, we will draw a qualitative analysis of the possibles specificities of *in-situ* management of biodiversity brought within such partnerships. Preliminary results will be presented at the conference.

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Poster in 3 min

From Cosmopolitan maize to Identitarian maize: collective management of maize landraces in France and Italy

Marianna Fenzi[1] Laurent Hazard[2] Nathalie Couix[3]

[1]INRA de Toulouse, France, https://www6.toulouse.inra.fr/agir, marianna.fenzi@gmail.com
[2] INRA de Toulouse, France, laurent.hazard@inra.fr - [3] INRA de Toulouse, France, nathalie.couix@inra.fr

Key words: Maize diversity, collective management, values, France, Italy.

Maize landraces in Mexico, center of origin of Zea mays, are assumed to be highly diverse and involved in farmer seed supply. In contrast, in industrialized countries, maize culture is associated with the use of hybrid homogenous varieties provided by seed companies and standardized agricultural practices. This study, based on farmers collectives from two regions of France (Aquitaine) and Italy (Veneto), aims to identify key practices and values involved in maize landraces management. We traced the rise and the transformation of collectives and analyzed their functioning regarding seed supply and breeding strategy. Moreover, to identify particular needs at the farmer level, we collected information about the structure of the farm, uses of maize, agricultural practices, motivation and concerns associated with their choice to grow maize landraces. Between April 2017 and May 2018, we conducted a survey based on observant participation during different phases of maize culture and on a semi-structured questionnaire used to interview 27 farmers involved with the "House of seeds" ("Maison de la semence") group in Aquitaine and 15 farmers belonging to local maize consortiums in Veneto. In Veneto, maize culture was strongly associated with its use for human alimentation while in Aquitaine animal feeding represented its principal usage. In Veneto, each consortium grew only one variety while in Aquitaine, even though there was a predominance of famers growing only one variety, we found a very high diversity at the collective level (for a total of 35 varieties grown). The proportion of farmers formerly growing hybrids and having completely replaced hybrids for landraces was 30% in the French group and 43% in the Italian group. More than 40% of the farmers still growing hybrids considered that it is possible to move toward maize landraces although they revealed their concerns related to the low productivity of landraces compared to hybrids. Concerning the choice to grow maize landraces, the main raison reported in Aquitaine was the opportunity to become autonomous from the formal seed market. Instead, the main reason reported in Veneto was the will to provide a better product to consumers and to conserve local traditional varieties. Main criteria of selection were the vigor of the plant in Aquitaine, considered a crucial characteristic to create a healthy maize population ensuring a good yield, and vitreous kernels and color in Veneto, elements needed to maintain the characteristic quality of polenta. The study of maize diversity management reveals a complex relationship with the history of different productive patterns and of the place given to maize. Farmers in Aquitaine have "reconstituted' their maize landraces from a very broad panel of maize populations ("cosmopolitan" maize). In contrast, in Veneto, each collective takes care of a particular landrace anchored in the community ("identitarian" maize). This diversity and even divergences in functioning, imaginary and practices allow continuous development, maintenance and creation of maize diversity.

Table 1 - Cultural and agronomic aspects related with maize landraces culture in the Aquitaine and Veneto group.

Regions	**Hybrid vs Landraces trends**		**Reasons for growing maize**			**Agronomical aspects**	
	Farmers, growing hybrids in the past, replacing completely hybrids for landraces	Farmers still growing hybrids declaring it is possible to shift to landraces	Became autonomous from the formal seed market	Conserve farmers crop diversity	Offer better product to consumers	Farmers growing maize without water	Farmers' first criteria of selection
Aquitaine	30%	51%	89%	55%	37%	81%	Plant vigour
Veneto	43%	46%	53%	80%	100%	78%	Vitreous kernels

(1a) (1b) (1c) (1d)

Figure 1. (a) Maize Marano collective selection and (b) maize mill in Italy. (c) Different maize varieties harvested and selected by a single farmer and (d) seed maize drying above crowns eating maize silage in France.

Poster in 3 min

Governance and organizational models of informal seed systems in Italy

Livia Ortolani, Bettina Bussi, Riccardo Franciolini, Matteo Petitti, Riccardo Bocci

Rete Semi Rurali, Via di Casignano, 25, 50018 Scandicci (FI), Italy, www.semirurali.net, info@semirurali.net

Key words: Community Biodiversity Management, Agricultural Knowledge and Innovation systems, Governance models.

Background

Community Biodiversity Management contributes to the empowering of farming communities to manage their biological resources and to the sustainable use of agrobiodiversity (De Boef et al, 2013). The main aim of CBM is described by De Boef et al. (2013) as the use participatory processes to build community institutions and strengthen their capabilities of conserving and sustainable use Plant Genetic Resources and has been used to look at case studies from developing countries. However, the DIVERSIFOOD project looked at the application of the Community Biodiversity Management approach in Europe with a different approach, learning from existing experiences of multi actor network working at local level as collective experiences of community biodiversity management.

Main Chapter

This study uses the Community Biodiversity Management framework to look at the governance and organizational models of 10 collective experiences developed in Italy at local level using a bottom up approach. The goal of this study is to present cases that have been identified by the authors not just as experiences of sustainable use of agrobiodiversity but also as innovative organizational solutions to design future local seed systems.

The use of this approach allows considering how socio-environmental changes influence the seed management strategies of local communities and public institutions. At the end of the 90s a process of institutionalization of agrobiodiversity conservation start to develop in different Italian regions with regional laws and finally with the National Law 194/2015. The focus on supporting individual experiences rather that collective ones, made this process often representing a blockages rather than a leverage for the development of local collective experiences of seed networks. However, some experiences of multi actor networks aiming at conserving and facilitating the use of agrobiodiversity developed with a participatory and bottom up approach in different areas of the country. Those experiences represent interesting cases of agricultural knowledge and innovation systems (EU Scar, 2012).

The authors looked at seed production with a wide perspective that include the whole seed system, integrating different activities: from the searching for new varieties to the seed quality, from the participatory research to the possible relationships that can be developed with the private sector and the market to valorise the production derived from agrobiodiversity. All those activities have been considered as part of an informal seed system based on local collective experiences in which different actors, either directly or indirectly connected to seed production, exchange knowledge and collaborate with a mutual learning approach (Klwerxx et al. 2012).

A long-term interaction with actors embedded on different networks allowed describing the organizational model of each experience through several informal meeting and knowledge exchanges. Modelling the decision-making behaviour of each system underlined its governance structure and the different actors covering different roles depending on specific factors, such as the specific context and the personal motivation of individual actors. The description of several experiences using the same methodology gives space for comparison and generalization. An interesting finding is that trust and constant maintenance of relationships between all actors of the systems are two key factors of success.

The poster will present examples of the social model describing the organizational structure of 10 informal seed systems in Italy.

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Poster

A novel scientific base underlying the traditional seed exchange by farmers

Dionysia A. Fasoula[1], Michalis Omirou[2]

[1] Agricultural Research Institute, Department of Plant Breeding, Cyprus, www.ari.gov.cy, dfasoula@ari.gov.cy

[2] Agricultural Research Institute, Department of Agrobiotechnology, www.ari.gov.cy, michalis.omirou@ari.gov.cy

Key words: Community seed banks (CSB), interplant competition, seed degeneration, nonstop selection

Background

The traditional practice of seed exchange among farmers has been documented since ancient times and it has been empirically associated with obtaining (or believing to obtain) lower yields if seed is not replaced (Zeven 1999). Despite the widespread occurrence of this phenomenon, that also finds its expression in the modern community seed banks (CSB), an explanation for it is not commonly discussed in the scientific literature. Nevertheless, it is possible to provide a rigorous scientific explanation to the various empirical observations of seed exchange when considering the established (Kyriakou and Fasoulas 1985) and precisely measured (Fasoula 1990) negative correlation between yielding and competitive ability that interferes with the effectiveness of selection of the "best" seed destined to serve as seed source for the next sowing period (Fasoula 2011).

Materials and Methods

At the Agricultural Research Institute in Cyprus we have undertaken long-term studies of the variability within a local cowpea landrace named "Argaka". This landrace has a prostrate growth habit and is characterized by its ability to provide fresh pods in consecutive harvests that command good market prices as a traditional, healthy food in local cuisine. The first year, about 700 plants from the landrace were sown in an unreplicated honeycomb selection design (Fasoulas and Fasoula 1995) at ultra-wide distances that exclude inter-plant interference and competition. Selection of 19 superior lines on the basis of fresh pod yield at the level of the individual plant led to the establishment of subsequent honeycomb trials to continue selection for a period of seven (7) years that is still ongoing.

Results and Discussion

The results of seven (7) years trials on continuous selection for improved fresh pod yield within the landrace "Argaka" demonstrate the existence of a so-far inexhaustible variation that allows the nonstop, incremental improvement of this landrace without any introduction of foreign genes. In addition to the consistent higher yields, the improved lines possess improved vigour and overall visual appearance. At the same time, we documented the existence of cryptic, detrimental variation, manifested in traits like sensitivity to photoperiod, bareness, and reduced pod yield. Plants with the above traits consume substantial resources to the detriment of the more productive plants and produce a delayed and limited, or even absent, number of pods, in only a few of the consecutive harvests. However, such plants remain undetected and escape roguing due to the densely planting conditions that prevail in farmers' fields when they prepare their farm-saved seed for the next season. The data fully support the results obtained in wheat and cotton (Fasoula 1990; 2012).

Conclusions

Results of this long-term study confirm and further demonstrate the importance of practicing nonstop selection, a key principle associated with the honeycomb breeding (Fasoula and Fasoula 2000), to avoid the seed degradation and cultivar degeneration following the conventional seed maintenance procedures. The value and essence of nonstop selection has been recognized and included in the recent (2017) recommendations for on farm conservation and management of plant genetic resources for food and agriculture by the ECPGR.

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Session 5

Lessons learnt from value chains studies in Diversifood: factors in support and hindering their success

Keynote

Strategies to add the values of agrobiodiversity in food chains

Bernadette Oehen[1], Adanella Rossi[2]

[1] FiBL-Research Institute of Organic Agriculture, Frick, Switzerland, bernadette.oehen@fibl.org
[2] Department of Agriculture, Food and Environment, University of Pisa, Italy, adanella.rossi@unipi.it

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Background

The current food supply chain is characterised by a highly standardised and monotonous offer produced in an impoverished agricultural system. It is widely acknowledged that the narrowing of diversity in crop species is a threat to food and nutrition security, due to lower crop and variety diversity available for farmers and a loss of adaptability of crop systems to a changing environment. At the policy level, since the early 1990s the topic of agrobiodiversity has progressively come to the fore and has become the subject of actions and policies of international institutions. At the same time, and often as a reaction to the uncertain progress of politics, movements linked to farmers/peasants and civil society organizations evolved and started facing the problem of the necessary recovery of agrobiodiversity. In Europe, examples of these movements are *Arche Noah* (Austria), *Pro Specie Rara* (Switzerland), *Rete Semi Rurali* (Italy), *Red Andaluza de Semillas* (Spain) or the *Réseau Semence Paysanne* (France). Furthermore, agrobiodiversity has seen an increasing engagement by a part of the public research sector. The picture that has been derived from this growing interest is thus variegated and dynamic, covering different actors and their views and strategies for maintaining genetic resources (ranging from *ex-situ* to *in-situ* conservation and, increasingly, collaborative management of agrobiodiversity). In addition, consumers have been showing a growing interest in and sensitivity towards agrobiodiversity. This is giving rise to new opportunities for cooperation between producers and consumers.

The DIVERSIFOOD project focused on initiatives that aim at enriching agrobiodiversity in food systems and are promoted by hybrid networks, including farmers, other chain actors, scientists, facilitators, advisors, and, in some cases, public authorities. We see the cultural and economic valorisation in the market as a key factor to re-introduce diversity into the food chain and to guarantee the sustainable use of diverse genetic resources (Fig. 1). So, in one of the work packages of DIVERSIFOOD (WP5), we analysed the factors and processes underlying the strategies that aimed to add the value of agrobiodiversity in food chains.

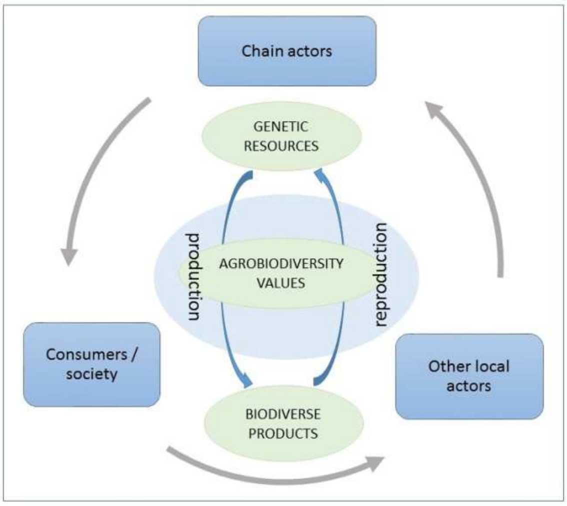

Figure 1: The virtuous circle of sustainable management of genetic resources: cultural and economic valorisation of biodiverse products as a key factor to re-introducing and maintaining diversity in the crop-food systems.

Our approach

In DIVERSIFOOD, we looked at the re-introduction of diversity in food systems through a social-ecological lens. We assumed that increasing diversity on fields and plates is a complex process that builds on the awareness of multiple values of agrobiodiversity (environmental, ethical and cultural) and the translation of this awareness into proper practices. These processes cover all the stages involved, e.g. breeding, crop production, food processing, and diet patterns, and develop through the interactions and contributions of multiple actors, diversely involved in the process, and with different perspectives. In turn, these processes involve different domains, which refers to technical, organisational, cultural, social, economic, institutional, legal and political dimensions. Moreover, these dimensions are often closely interdependent.

All this shows the importance of adopting a comprehensive, systemic approach in dealing with the topic and the need to pay special attention to the role of the various actors involved, to their interaction, as well as to the processes stemming from this interaction. Particular attention should be given to the learning processes underlying awareness building, the alignment around shared views and goals, and the development of new, consistent practices (Brunori et al., 2018). Such an approach is considerably more complex than traditional marketing strategies to promote quality products in the market. Here, marketing is conceived as a strategy that involves the whole supply chain around the creation and appreciation of value. The focus is laid on the social

processes underlying the development of a collective engagement around resources that are perceived for their social values and, in some cases, even positioned within a broader framework of food sovereignty and common goods management.

During the project DIVERSIFOOD, we applied this general approach in eleven case studies that were conducted in cooperation with the project partners in eight different countries (Tab. 1). A common analytical framework was developed (Rossi et al., 2016), to explore the above mentioned dimensions in five critical areas of interaction: mobilisation of genetic resources, definition of specific quality attributes, marketing and communication, interaction with other networks and projects, and effectiveness and sustainability of the initiative. Based on the framework, we comparatively analysed the functioning of value chains built around food products stemming from diverse genetic resources. The analysis was conducted in two separate sections, respectively focussing on eight case studies selling products from underutilized vegetables and grains, and on three cases of marketing of products from newly-bred lines from participatory plant breeding (PPB) (Padel et al., 2018).

An important methodological aspect in applying the framework has been that the study was built on close cooperation between the scientists and the actors in the case studies, according to the transdisciplinary approach adopted for the whole project. This covered participation in the development of the research questions and execution of the study as well as feedback-loops to comment on the findings.

In parallel, we compared different label strategies (Holzherr et al., 2018), conducted a survey to assess consumers' awareness of food diversity and agrobiodiversity in four different European countries (Meier 2018). In this note, we focus mainly on the findings and lessons learnt from the case studies (Tab. 1).

Table 1: Compilation of case studies investigated in the course of DIVERSIFOOD

Case study topic: Products from underutilized crops		**Case study topic: Bread from wheat varieties, landraces and populations from PPB**
Production of heirloom tomatoes for gastronomy through a network including farmers, an organic farming organisation and research institutes (Austria).	A project involving farmers and researchers to develop value chains for local varieties of wheat used in artisanal bread, pasta and other cereal products (Spain).	Bread making from a national PPB wheat programme involving a wide network, aimed at developing new population-varieties adapted to organic agriculture, free of intellectual property, farmer-managed (France).
Production and promotion of landrace tomatoes to increase tomato diversity for farmers and consumers involving a network of farmers and researchers (Hungary).	Conserving traditional maize varieties for bred use - *Broa bread*. Local stakeholders have engaged in building up a new, sustainable maize bred value chain development (Portugal).	Promotion on the market of seeds and products derived from a hugely diverse population suited for organic and low-input farming systems (UK).
Breeding, conserving and adapting heritage vegetables in a network of breeders and volunteers (Switzerland).	Marketing of emmer and einkorn products. The cereal varieties are bred in a national breeding programm and should offer a subsitut for spelt for organic farmers (Hungary).	Three regional initiatives, involving networks of farmers, processors, researchers and facilitators, engaged around organic cultivation of old wheat varieties, landraces and populations, and traditional bread making (Italy).
Varieties of purple carrots preserved by local farmers and gardeners for generations. Networks aim to collaborate to recover and commercialise production, heritage and genetics of these varieties (Spain).	Networks of farmers and bakers in producing different cereals for pasta, bread, biscuits, flour and beer; the products are marketed as having health benefits and a link to the local heritage (Italy).	

Findings and lessons learnt

The initiatives analysed are different in their approach to agrobiodiversity preservation and enhancement, because of different driving factors, such as type of promoter and actors' motivations, and/or different ways of development. This variety, combined with relevant common features, has provided useful insights.

The study confirms that a systemic approach - in relation to all the different dimensions involved in the different stages of the valorisation process - is needed to understand the processes linked to the development of the initiatives and to support them. Based on the multi-actor nature of these processes, another important finding is that coherence of vision, values and knowledge among the actors directly involved - from the fields to the plate - is crucial to the success of any initiative.

A cornerstone for strengthening and promoting an entire production and consumption system based on diverse genetic resources is indeed interaction along the entire supply chain. Equally important is the exchange within

networks including other actors such as researchers, consultants and facilitators, who contribute to the development of the system. Within this collaborative environment, actors may share different forms of knowledge, views, and expertise and may cooperate and define common goals. The collective learning that takes place within these interactions indeed supports most of the processes involved in the various stages of the valorisation strategy. It is, for instance, at the root of the development of a common understanding of the distinctive quality of the diverse genetic resources and of the special qualitative attributes of the derived food products. These shared knowledge and vision in turn underpin the needed re-definition of the practices of farming and processing. They also support the fine-tuning of suitable tools and arrangements along the chain (e.g. codes of practices, norms and rules), which are important to consolidate the new practices and the relationships among the chain actors. Not last, having access to knowledge and mutual learning proves to be attractive and supportive for farmers and other supply chain actors to get involved.

A significant combination of different types of knowledge (experiential, scientific), of fields of expertise (e.g. on technical, institutional or legal aspects) and awareness (e.g. of political implications), held by the different actors involved, characterises these processes. Such an enriched common pool of knowledge and competencies allows the initiatives of valorisation to face the technical, organisational, institutional and legal challenges associated with the management of the diverse varieties and landraces or heterogeneous genetic materials.

The importance of internal coherence of knowledge and vision also emerges in the management of marketing and communication aspects. The initiatives that were analysed showed clear differences in terms of marketing solutions, ranging from territorially embedded niche markets, in the forms of short chains, to presence in the conventional big retailers, aiming at building up the market of biodiverse products. A common critical factor is the capacity to preserve the values embodied in the food products and to communicate them properly, thereby involving consumers in their appreciation. In this regard, the different marketing options see the significance of specific aspects. In longer chains, the capacity to define proper tools to manage the products on the market - such as agreements along the chain, labels, trademarks, logos and forms of protection from misappropriation - becomes crucial to overcome the limits coming from the lack of direct relationships between production and consumption. Where the relationships are closer, the capacity to convey the special meanings of biodiverse products and to translate them in economic value relies more on the quality of interactions between the parties. However, also in these cases, labels or logos to accompany food products or, earlier, seeds, prove to be strategical to highlight and share the special values they embody. Significant dynamics emerge here, in relation to how biodiverse products are positioned in the market and perceived by consumers: they may i) be attractive merely for health or organoleptic reasons, ii) be integrated into the local food traditions, thus identified with a place, or iii) may be more importantly linked to the local production system and the associated commitment to the management of genetic resources. The first type of positioning/perception a product on the market is an increasingly easy entry point, because tast and health are relevant food attributes for consumers. The second form is linked to an increasing consumers' interest in local and traditional food, preferred over industrial food. Both strategies, however, show the need to develop a greater awareness of the deeper values of biodiverse products and of implications of agrobiodiversity conservation-enhancement among consumers. This for instance means including the specific genetic background of seeds and their local adaptation to the environmental and socio-cultural food habits in the local/regional dimension. The third form of positioning/perception refers to the embeddedness of biodiverse products in the social system that links seed savers, farmers, processors, consumers, researchers, and facilitators around the management of crop-food diversity; here, the product quality covers social dimensions like 'community' and seed and food sovereignty/autonomy that the product stands for. This is a more challenging strategy implemented by some of the networks that were analysed. This progressive increasing engagement of consumers shows how they may play a role that goes beyond being mere recipients of valorisation strategies. Consumers are invited to develop greater awareness as well as sense of belonging to and willing to participate in collective strategies for sustainability of food systems.

The approach to biodiverse product quality is associated with the choices concerning the model of development. Many of the cases studied reported ethical dilemmas in deciding how best to develop their supply, or 'scale up', without compromising their commonly shared principles based on environmental sustainability, farmer empowerment, and embeddedness in local contexts and cultural heritage. This is reflected in the fact, that some of the cases are not interested in scaling up their business, but rather in articulating it better (scaling deep) or in sharing their experiences and allowing others to replicate them (scaling out). The research has thus shown that there is not a one-size-fits-all approach for developing. More nuanced approaches are needed to better suit the motivations and visions on which the initiatives are founded, and the features of crop systems and product(s) that they are trying to promote.

The cases show, however, that the local dimension of business is a fundamental component of the development of the production systems and of the market valorisation strategies. It allows the interactions among the chain actors that contribute to the specific quality of products, in its turn stemming from the management of the diverse genetic resources in the specific contexts. Local and short supply chains facilitate the interaction with consumers, communication of quality, trust and transparency in the story of the product, so favouring a stronger engagement

of consumption practices in the local food systems. This allows people to overcome that condition of distance, both in miles and minds, which is considered as a main driver for unsustainable food consumption (Reisch 2013). The local dimension also provides a further model for scaling: a growth of the production-consumption systems through an increase of the number of enterprises involved (farmers, processors, intermediate users, retailers). Of course, conservation of agrobiodiversity and sustainable consumption patterns are not only a matter of consumer choice. Only in combination with policy measures, as detailed later, consumers can contribute to achieving more sustainable and resilient food systems and healthier diets.

The potential of interaction and associated collective learning, alignment and cooperation emerges once again when considering the connections established with other networks and pathways, both locally and in broader contexts. These have proved to be important to strengthen the initiatives, catch new opportunities and further develop collective awareness, identity and agency around agrobiodiversity management issues. All the stages (from farming to marketing) and dimensions of the valorisation strategies (from technical to cultural and legal aspects) are involved, which results in a powerful condition for the consolidation and the sustainability of valorisation initiatives. In a context of growing interest in crop-food diversity by the agro-food industry and big retailing chains and with increasing openness by policy makers, this broader collective dimension in handling the issue appears extremely meaningful, guaranteeing synergies as well as preventing losses of effectiveness.

Together with the need for internal coherence, the initiatives we analysed also highlight the importance of the existence of an enabling external environment to support production-consumption systems in their efforts to enhance agrobiodiversity. This first relates to suitable policies for genetic resources management (seed production and circulation). Indeed, the analysed networks share the view that current seed laws and policies are not designed to promote diversity in agricultural systems and thus hinder food diversity. For this reason, lobbying for better seed legislation is an essential task for many of these networks. More in general, more conducive policies are needed at breeding, farming, marketing and consumption levels, which should aim at creating favourable conditions for the various actors involved to play an active role and to contribute to coherent collective strategies of enhancement of agrobiodiversity. This may be the case with consumers' role, as above said, but, in a broader multi-actor perspective, this also relates to the role of farmers - who need support in such a challenging reorganisation of activity; researchers - who should be encouraged and supported in adopting the needed participatory and transdisciplinary approaches; facilitators - whose role proves to be crucial in bridging knowledges and fields of action; and, no last, regional/local public authorities - who need to acknowledge their role in favouring innovation, and to be available and able to create new spaces for experimentation and governance. Such an empowering process should build on the potential of the network dimension and of the locally adapted solutions. In this regard, the model adopted by EU policies for innovation (EIP-AGRI), stressing the role of networks and interactions, is showing a promising approach.

Drawing on all the research done in the WP on valorisation strategies, we have further elaborated recommendations for policy makers in the Deliverable 5.4 of the project (Policy Recommendations), as well as we have prepared guidelines for practitioners in a technical booklet under WP6, illustrated with examples of the case studies.

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Oral

Embedding food diversity in supply chains – Experience of eight European case studies

Anna Sellars[1], Susanne Padel[1], Bernadette Oehen[2]

[1] Organic Research Centre, UK, country, www.organicresearchcentre.com, anna.s@organicresearchcentre.com, susanne.p@organicresearchcentre.com

[2] FiBL, CH, www.fibl.org., bernadette.oehen@fibl.org

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Background

The main objective of this socio-economic analysis of value chains is to produce guidelines and recommendations for food diversity through value chain development for underutilised crops. To encourage more producers to grow a great diversity of crops it is necessary to explore how old and forgotten species and neglected germplasm of common crops can be revived, and this diversity embedded in the supply chain in new and innovative ways. We aimed to learn from the experience of eight cases, considering the perspectives of different actors from farmers to consumers. We studied the aims of collaborative marketing and valorisation strategies and gained a better understanding of production, processing and communication strategies, the development of the networks and learned about factors of success.

Approach

The case study is an investigation of a contemporary phenomenon in the real-world context (Yin, 2014). Here we carried out the comparative analysis of eleven initiatives developing biodiverse products in six countries involving partners of the Diversifood project (Tab. 1). A common framework considered five critical stages of development: mobilisation of genetic resources, definition of specific quality attributes, marketing and communication strategy, interaction with other networks and projects, and evaluating the effectiveness and sustainability of the initiative.

The common approach included setting out the background of the specific conditions, interviews with initiators, producers and other stakeholders about production, processing and marketing strategies, and focus groups or interviews with consumers. The national teams developed a list of stakeholders and selected interview partners, aiming for five interviews each with farmers, with supply chain actors (processors, traders, retailers, millers, cooks), and with other persons relevant for the initiative (consumers directors, president, product manager, funders, scientists). In total 121 interviews were carried out.

Table 1: List of case studies of developing marketing for products from underutilised cereal and vegetable crops

Vegetables	Alternative cereals
Heirloom tomatoes, Austria	Heritage cereals, Spain
Landrace tomatoes, Hungary	Broa bread, Portugal
Heritage vegetables, Switzerland	Emmer and Einkorn products, Hungary*
Purple carrots, Spain	Alternative cereals, Italy

Results

The case studies

The cereal-related initiatives in Italy, Portugal and Spain include farmers growing local varieties of wheat or maize that are used in artisanal bread, pasta and other cereal products. They collaborate with organic and artisanal millers and bakeries, pasta processors, and retailers. They are also connected with research institutes engaged with genetic resources and in most cases also with NGOs and initiatives dealing with seed diversity. In the Hungarian case, the introduction of two species (Emmer and Einkorn) not commonly grown in Hungary for beer as well as bread, pasta, flakes, cookies, and crackers were studied. All grain-related initiatives emphasise the higher nutritional value of the species and varieties grown.

The vegetable initiatives aim to support the use of open-pollinated varieties and decentralised on-farm breeding to create seed sovereignty as well as distinct product qualities. There is a strong emphasis on collaborative learning, for example testing the agronomic characteristics of used cultivars or varieties, with members sharing

skills and experiences. The range of species covered is considerable: two initiatives work with tomato varieties and explore different marketing opportunities for the varieties both for raw and for processed products; the Spanish initiative focusses in purple carrots; the Swiss initiative of Pro Specie Rara (PSR) covers old varieties of broad range of species and the marketing of the vegetables under the PSR label through a national multiple retailer, but also, in this case, there is strong emphasis on knowledge sharing, collaborative learning and improvement of the genetic resource.

The example of the Broa bread network in Portugal

This network consists of farmers, breeders, researchers, and local millers, bakers and shops who sell maize bread that has been traditional to the area for generations. In the 1960s, Portuguese maize breeders started a collection of regional maize germplasm, which now covers more than 3000 accessions. Since 1980s, in-situ/on-farm conservation, initiating participatory plant breeding (PPB) programs exist, focussing on breeder and farmer needs. The final product is a regionally specific type of maize bread, distinct from much of the maize bread in the domestic market; it is reported to be of higher quality and taste, and requires traditional recipes and methods of baking, so it is considered of high cultural capital in the region. Despite this the market is relatively undeveloped, being maintained through loyal customers in niche local bakeries and markets.

Mobilisation of genetic resources

The results show that all initiates have the common aim to preserve the biodiversity of local and/or heritage crops, but differ in how they originated. Some initiatives arose from the interest of producers in seed conservation, others from businesses recognising a demand for specific niche products, and in some cases, researchers were strongly involved in setting up the initiative.

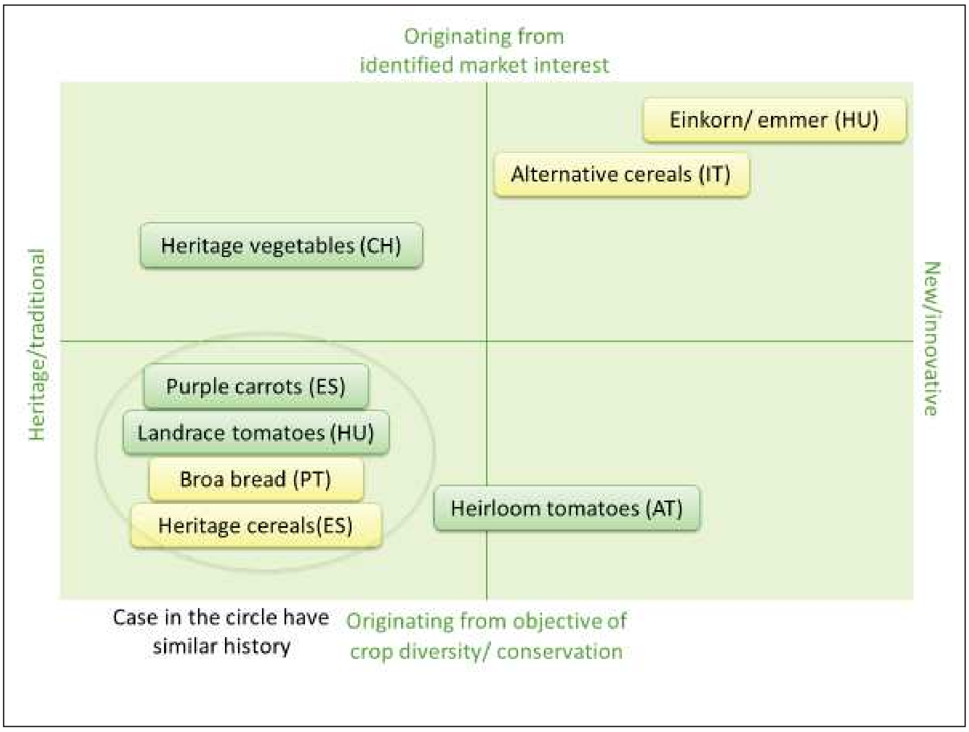

Figure 1: Characterisation of the case study initiatives according to main aims and motivations. Source: Own data

Some cases (see Figure 1) were driven by a strong commitment and longstanding belief in biodiversity conservation and seed sovereignty, at either from the producer or consumer end of the value chain. Of the case studies, these include purple carrots, Broa bread, heritage cereals in Spain and the two initiatives for landrace/heirloom tomatoes. These initiatives are therefore more resilient to fluctuations in market trends than those originating mainly from marketing specific product characteristics (such as superfoods, or the recent boom in gluten-free markets). Financial returns are considered secondary and many of these initiatives were sustained at least in part through the work of volunteers.

Some other initiatives were led by actors aiming to meet a perceived demand, e.g. for nutritious or quality products, or to diversify the product range and enter new markets. This is the case of heritage vegetables in Switzerland, and the alternative cereal initiatives in Italy and Hungary, relating to a growing interest in low- or no-gluten alternative grains. Some of these more market-oriented cases experienced difficulties in meeting demand due to lower yields, limited access to seeds, unsteady supply and higher wastage in the value chain that

non-conventional crops often face. This challenges the assumption that a limited market demand is usually the limitation for biodiverse food products.

A second characteristic of the case studies was the distinction between those that emphasised 'innovative and new products' or 'heritage and tradition' as core values in the marketing of the products. Traditions, culture and heritage of old varieties and the desire for something slightly special or different, were values that all stakeholders along the supply chain identified as important for their interest and involvement. This included farmers who had been growing and saving seeds from old varieties for years, but also chef cooks and consumers who wanted a unique taste and visual characteristics from the food that they buy. The Swiss case study of heritage vegetables highlights that products need to offer more benefits and selling points than just being an old variety to ensure a sustainable market demand, particularly when collaborating with mainstream retailers. Crop heritage remains important, but marketing such a product requires the identification of other 'new and innovative' characteristics to be successful and meet consumers' interests. Also the Hungarian case, where emmer and einkorn are used as alternative to Dinkel, highlights the opportunities provided by crop diversification in establishing new markets, regardless of local heritage.

Seed availability is a key concern for many of the cases studied, and for several is reported to be a limiting factor in the ability to supply increasing market demand. In the case of Hungary, the only domestic seed available is through the seed and grain trader Naturgold, to whom they are legally obliged to sell the crop back to once harvested, limiting their autonomy to establish independent sales channels of their own without importing seed. Seed saving also raises issues of the quality and authenticity of seeds. This is particularly apparent in the case of Switzerland where voluntary seed production is providing germplasm for products supplied to a mainstream retailer, creating unreliability in the consistency of both the product and of supply. Increasingly the thinking seems to progress beyond searching for old germplasm towards more adapted cultivars.

The need for adaptation of agronomic practices is a common reality of working with heritage, alternative and local crops, and relates to machinery, spacing and rotation of crops, application of different/additional, or acquisition of knowledge specific to varieties that are new to farmers (this is particularly relevant to cases like Emmer and Einkorn in Hungary where there is little or no experience of farmers growing the crop). This can result in problems in recruiting a sufficiently large producer base that may result in limiting production and thus market development.

Often the non-standard and heterogeneous characteristics of alternative/heritage varieties also demand adaptation to the processing, storage and distribution of the product to ensure quality is optimised. These can be challenging and problematic (for example the drying out of fresh pasta in transportation as observed in Spain), although visible differences in the product can offer an opportunity to more easily differentiate the product from consumers' regular expectations.

The definition of specific product attributes

Initiatives that originate from the aim of protecting genetic diversity can struggle in establishing market interest and in developing demand, especially for unusual products. Opportunities arise from the cultural capital of a local identity and heritage, but the preservation of otherwise 'unviable' crops will require finding innovative ways of processing, for example by developing 'food communities' around the value chain.

Some of the more market-oriented initiatives took advantage of existing trends (e.g. superfoods and health markets) which have potential to grow the market beyond the immediate local area. Websites and social media are widely used to communicate the values of such products. Problems with meeting demand (due to lower yields, unsteady supplies and wastage in the value chain) challenge the common assumption that the most limiting factor for the development of biodiverse supply chains is likely to be a lack of consumer demand.

Developing a marketing and communication strategy

Common challenges related to identifying and communicating the 'story, were identified: i.e. the value of the diverse product to consumers, a lack of secure and good quality seed supplies and, in the case of cereals and in the processing (e.g. baking with low-gluten flour).

Several of the initiatives studied described ways in which actors are moving beyond their initial value chains, oriented around largely vegetables, bread and pastas, to more innovative products and services to expand their market opportunities. The success and public interest in the einkorn beer value chain in Hungary has capitalised on the novelty of both new endproducts and einkorn as an alternative cereal. As a result, it is able to support the up-scaling of cultivation and conservation of alternative varieties, as well as facilitate new end products, such as alcohol-free beer, and beer from other niche cereals.

Some more developed case studies are reaching markets through collaboration with other stakeholders, for example multiple retailers that have skills and resources to facilitate sales. The case of PSR illustrates that collaboration between a non-profit, volunteer-based farmer network (PSR members) and one of the country's

leading food retailers is viewed as both good and bad by stakeholders and seen as a 'balancing act' of expectations and priorities of both sides.

The effectiveness and sustainability

Regular communication with all actors is important for creating cohesion of values and the direction for business development. This is the same whether the initiative is mainly a network of farmers or a broader network extending to processors, retailers and researchers. Therefore, having coordination in place to help build relationships of trust is essential, particularly for initiatives that have not naturally 'self-organised'. Lack of coordination can also lead to logistical problems. With many producers in these initiatives operating on a small-scale, coordination of the collection of produce would be beneficial, but that involves complexity and requires an actor to take responsibility, which is challenging in a fragmented network.

Conclusions and recommendations

Limiting factors (e.g. lack of seed supply, low yields and margins for producers) should be considered in an honest way when developing business plans. There is a need for more nuanced marketing strategies, considering not only local and potentially very limited, but also national outlets and markets. **Combination of different supply chains** can prove to be very useful in building flexibility, resilience and support for core aims of the initiative that might otherwise be economically unviable.

Some of these more market-oriented cases experienced **difficulties in meeting demand** due to lower yields, limited access to seeds, unsteady supply and higher wastage in the value chain that non-conventional crops often face. This challenges the assumption that a limited market demand is usually the limitation for biodiverse food products. In all cases, **research support** can be important in relation to all stages of the supply chain, such as breeding, agronomy, product quality but also in establishing and better understanding consumer demand.

There is a need for all initiatives to develop a clear and shared understanding of the **product's distinctiveness** and **shared values** which needs to be agreed among members of the initiative as well communicated effectively to reach consumers. Interestingly, the network of tomato growers in Austria noted that **interest has shifted over the years** of the project from an interest in 'old' towards 'modern' varieties, suggesting that both growers and consumers are more interested in what makes the product different and diverse than its genetic heritage.

Case studies found the **mobilisation of cultural capital**, embedded in various labels or trends, useful in the targeting of products at particular consumer groups according to their respective interests, ranging from of 'heritage', 'traditional', 'artisan', 'local', 'gluten-free', 'eco-friendly', 'superfood', 'health food' and 'nutrition'. There was most success, where the marketing was able to identify narratives that consumers would identify with and find ways to communicate the vision and values of the initiative at the production end of the supply chain without compromising their integrity.

From the research and observations presented in this report, we make the following recommendations for the marketing of similar underutilised crops:

Develop a clear understanding among stakeholders of the distinctiveness and values embedded in the products (e.g. is it a new and innovative crop, or a traditional and heritage crop?), and communicate among stakeholders to establish a common vision and set of values.

Identify and develop a strategy to communicate the product in ways that suit the consumer(s), including personal vs. virtual engagement, and the potential use of labelling (messages, aesthetics and logos).

Consider the role of limiting factors at the supply end (in contrast to limitations at the demand end) in developing a marketing strategy, and what steps may be taken to either overcome them or adapt to them.

Challenge the assumption that initiative selling underutilised crops must select either a national/international marketing strategy, or a local/decentralised strategy; these can work alongside each other, and to complement each other, offering potential to diversify marketing channels and reach new consumer groups.

Recognise the role of research in supporting the implementation or adaptation of agronomic practices, in providing research evidence to marketing claims, or in expertise in labelling (e.g. introducing a Protected Designation of Origin).

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Oral

Ancient cereals in modern times: is there a future for underutilised cereals?

Boki Luske, Edwin Nuijten

Louis Bolk Institute, the Netherlands, www.louisbolk.org, b.luske@louisbolk.nl

Keywords: nature-inclusive farming, emmer, einkorn, rivet, wheat, triticum

Background

In the pre-industrialised era, cereals like rye and oat played an essential role in the Dutch rural landscape. These ancient cereals were a staple food for people and livestock. The straw was used for several purposes, such as groundcover in stables, and isolation and roofing material. During the last century, cereal production declined from 130.000 ha in 1950's to 106.000 hectares in 2017. At the moment, among the cereals, wheat is the most dominant crop (77%), followed by barley (18%). Cultivation of other cereals decreased drastically, such as for oats (1%), rye (1%) and triticale (0,8%) (CBS, 2017). Other cereals make up only 0,6% of the cultivated area. In the current market, Dutch farmers often make a loss on the production of conventional cereals (200 euro/ha loss) (PPO, 2012), due to the relatively high land costs and low prices for cereals on the world market. Most conventional cereals are traded on the world market as animal feed. Quality requirements for cereals for human nutrition are higher than for animal feed, with, for example, minimum protein levels of 12% protein in the Netherlands. High protein levels are requested as fast industrial baking processes need the protein for reaching a high and stable bread volume, which average Dutch consumers demand (Osman et al. 2007). The production of organic cereals is slightly more profitable than conventional cereals, but in general, the cultivation of cereals is under pressure in Dutch arable cropping systems

As a consequence, there is a shift towards the cultivation of cash crops like potatoes, onion and sugar beet, and tighter crop rotations. The reason that cereals are still cultivated in the Netherlands is that they have a function for maintaining soil fertility and controlling soil-borne diseases in cash crops of arable cropping systems.

Currently, there are strong social debates for transition in the farming system. One such transition is 'nature-inclusive farming' as the result of the serious decline of bees, butterflies and birds populations on Dutch farmlands. Nature-inclusive farming is focused on stimulating the functional biodiversity on farms in such a way that nature and farmer both benefit (Erisman et al. 2016). Wider crop rotations with more cereals or flowering leguminous crops are indicated as an important pillar for nature-inclusive arable farming (Koopmans et al., 2017). However, new business models need to be developed to make such a system economically viable. Another transition calls for diversification of crops based on a growing interest among consumers for healthy, tasty, quality food products from the region. So-called 'foodies' are especially interested in home baking of bread, using slow, traditional techniques for cooking and baking without the use of additives. Ancient cereals are assumed to have higher nutritional quality (Patijn et al. 2018), are suitable for slow baking techniques using sourdough instead of yeast, taste different from modern wheat and, at the same time, such ancient cereals are suited for nature-inclusive farming. Therefore, there seems to be a momentum for the cultivation of ancient cereals for local processing and consumption, and for developing local business models for farmers that can help to improve biodiversity. In this paper, we describe the agronomical performance and the socio-economical aspects for the development of local food chains for ancient cereals. Our research question was: is there a future for ancient cereals, and if yes: what are the conditions for a sustainable value chain?

Material and Methods

During three consecutive growing seasons (starting in October 2015) accessions of einkorn (*Triticum monococcum*), emmer wheat (*Triticum turgidum* subsp. *dicoccum*) and rivet wheat (*Triticum turgidum* subsp. *turgidum*) were assessed. The field experiments started with 7 einkorn, 13 emmer and 16 rivet wheat accessions. The available accessions originated from several seed banks from Diversifood partners in Hungary, Switzerland, France, UK and farmers in the Netherlands. The accessions were tested on an organic low input field near Bemmel, the Netherlands, part of a recreational nature area. Only solid manure was used and the soil was previous years in use for low input cereal production. Agronomic performance of the accessions was evaluated during the three seasons by researchers. Field meetings with farmers, bakers, and consumers were organised during the three growing seasons to select the most promising accessions for the Dutch circumstances. After each season a selection was made by combining the 'hard data' (records on plant diseases, lodging tolerance, plant height, timing of flowering, yields etc.) and the 'soft data' (selections during meetings, plant aesthetics etc.). In the second (2016-2017) and third season (2017-2018) the selected accessions were assessed in a replicated block design.

During the field meetings with farmers, bakers and consumers, information was collected on their perspectives on the potential uses of the ancient cereals. During the third field season, in-depth interviews were conducted with 5 key actors (3 farmers, 1 miller and 1 baker) from within the food chain of ancient cereals. Questions were asked about their experiences with the cultivation, processing and food chain development of ancient cereals. They were asked about their perception of agronomic constraints, difficulties in the processing stage, challenges for chain development and market opportunities. This information was triangulated with data on agronomic performance and from the field meetings.

Results

Agronomic performance on arable flora fields

The average einkorn yields in the seasons 2015-2016 and 2016-2017 were very low, in the latter season clearly suffering from drought in spring 2017. Yields in the season 2017-2018 were slightly higher. The best-adjusted einkorn accessions selected from these trials were the Dutch and British accessions, which hardly suffered from yellow or brown rust infections and developed strongly, reaching yields around 2 t/ha hulled cereals

The average emmer yields were very low in all three seasons 2015-2016, 2016-2017 and 2017-2018, due to respectively disease infections, poor tillering because of drought in spring 2017 and low soil fertility (Tab. 1). The best accession of the trials was Zweikorn with yields of 1.3 t/ha hulled cereals. Although most of the dark emmer accessions did not reach high yields, stakeholders chose the dark emmer accessions as favourites. This had to do with aesthetics: the remarkable colouring, the spiklets and shape and design of the ears.

The average rivet wheat yields in the first season (2015-2016) were also very low, mostly due to lodging. By selecting the shortest accessions with lowest disease susceptibility, we found the highest yield in 2017 of the Rampton rivet, amounting 2.3 t/ha naked kernels. Striking was that during the field meetings also the Rampton rivet was chosen by stakeholders as the most healthy looking accession.

During the field meetings, stakeholders were astonished about the beauty of the different einkorn, emmer and rivet wheat accessions. This was due to the different colours and shapes of the cereals, but it also had to do with the location. As mentioned before, the trial field was situated in a recreational nature area, surrounded by flowering herbs and field margins. Even within the trial field, typical flowers for arable fields appeared, like poppies, cornflowers and chamomile, but even some very rare Red List species were found in and next to the trial field. It was therefore not only a trial for agronomical performance, but also a trial for testing the suitability of ancient cereals on special arable flora fields. During one stakeholder meeting, we invited only ecologists, flora experts and nature organisations, to show them the accessions and ask them their opinion about the combination of ancient cereals and nature goals. All species were found to be suitable for low input production in combination with nature goals. Most nature related stakeholders showed interest in the dark emmer wheat and einkorn, mostly for aesthetic reasons.

Table 1. Number of accessions per species tested in the field experiment, range of yield and lodging tolerance rated from 1 (severe lodging) to 9 (no lodging). *For einkorn and emmer yields are hulled. **Due to limited available seeds in 2015, no replications were sown for most accessions.***Due to a problem with sowing Rampton rivet in 2015, no yield was measured.

	2015-2016			**2016-2017**			**2017-2018**		
	Nr of accessions	Av. yield ± st. dev. (t/ha)*	Log. tol.	Nr of accessions	Av. yield ± st. dev. (t/ha)*	Log. tol.	Nr of accessions	Av. yield ± st. dev. (t/ha)*	Log. tol.
Einkorn	7	1.4 ± 0.58	8.1 ± 1.57	7	0.8 ± 0.16	7.6 ± 0.17	4	1.9 ± 0.16	8.4 ± 0.60
Dutch einkorn	1	2.4**	7**	1	0.7 ± 0.18	7.5 ± 0.41	1	2.0 ± 0.35	8.8 ± 0.50
Emmer	13	0.6 ± 0.26	6.4 ± 3.10	9	0.9 ± 0.29	7.7 ± 0.45	7	1.2 ± 0.22	7.7 ± 0.66
Zweikorn GT-196	1	1.0**	9**	1	1.2 ± 0.50	8.1 ± 0.25	1	1.3 ± 0.10	8.1 ± 0.63
Rivet	16	0.8 ± 0.42	4.6 ± 2.94	9	1.6 ± 0.34	7.6 ± 0.42	4	1.8 ± 0.31	7.3 ± 0.66
Rampton rivet	1	***	7**	1	2.3 ± 0.66	7.5 ± 0.71	1	2.1 ± 0.40	7.8 ± 0.50

Social food chain analyses

According to the interviewed stakeholders, the development of a food chain with ancient cereals like einkorn, emmer and rivet wheat is not simple in the Dutch context, but possible. Several key aspects were mentioned for a successful product chain.

<u>Building social capital</u>

Each of the interviewed farmers mentioned that personal relations with product chain partners (millers and bakers) were essential. All three farmers spent a lot of time on storytelling, meetings and networking at different levels. Confidence or trust in product chain partners was mentioned as an important social aspect for the development of sustainable product chains of underutilised crops. Product chain partners should be able to rely on each other. To enable this it was advised to make clear operational agreements with the food chain partners.

<u>Knowledge about ancient cereals</u>

The miller and baker mentioned that there is a knowledge gap among bakers about the baking processes of ancient cereals. The regular education and training institutes for bread baking are still rather conservative, but apart from that, there is a growing group of bakers that are eager to develop and train themselves in slow baking processes. Recently, a national network of farmers and bakers started to increase the knowledge about the cultivation and processing of Dutch cereals, including the ancient cereals at the Diversifood trial field.

<u>Demand of consumers</u>

What is missing at the moment is a clear view about the demand of consumers for high-quality bread from ancient cereals. Bread is a staple food and Dutch food culture, in general, is focussed rather on quantity, high volume and low price. However, there is just a small – but growing- group of consumers and bakers interested in high-quality bread with good taste. Informing consumers about the nutritional and ecological benefits of locally produced bread from ancient cereals is needed, to support a growing demand for these cereals. Scientific research on this topic and translation into education and non-scientific media (including the use of social media) is therefore needed. With that knowledge, more consumers will ask their bakers for bread from ancient cereals.

<u>Push and pull</u>

From the various interviews, and earlier projects, a few farmers really interested in the cultivation of ancient cereals often functioned as 'push-factors'. Obviously, the interviewed farmers have an intrinsic motivation to work on this. They are passionate about the ancient cereals and want to transmit this passion via high-quality bread to the consumers. They motivated local bakers and millers to work with the produce, and sometimes also involved other farmers to grow these cereals. One baker involved in the evening field meetings with consumers and bakers also functioned as push factor: making other small-scale bakers interested in working with these ancient cereals, also by writing articles for bakery journals and circulating information on social media. These push-factors can stimulate the demand by consumers. Enthusiastic stakeholders do not automatically find each other to develop a food chain together for these niche products. Additionally, baking with locally produced ancient cereals means that you have to plan ahead: it takes at least a year from sowing to flour (cultivation, dehulling, milling). Most bakers are used to order what they need at their flour supplier only when they need it, but these locally produced ancient cereals are not available in large quantities. Mills often do not have the capacity to store stocks of different flour types, and only run when there is an order for speciality cereals.

<u>Food chain management</u>

Planning of sowing, potential yields and sales are essential. All interviewed farmers contacted there food chain partners before sowing. In the case of ancient winter cereals, this means that the farmers organised a meeting (or did a telephone survey) in September, to inventory the future demand of the millers and bakers. As it takes at least a year to grow, dehull, clean and mill the cereals to flour, this planning is essential for the continuity of the food chain. And it demands commitment from the food chain partners to agree upon future sales. The three interviewed farmers were food chain manager at the same time, organising logistics, storage and marketing, communicating the historical background, food quality aspects and ecological aspects of the ancient cereals. In one case baking even took place on the farm itself. Two of them were actively involved in product development and looking for new food chain partners like producers of beer and pasta.

<u>Storytelling</u>

At the moment the farmers and certain bakers involved also play an important role in storytelling, informing all sorts of chain actors about ancient cereals, the history behind it, the ecological benefits and the nutritional value. However, there is more knowledge requested, so bakers, who have the direct link with consumers, can also tell these stories.

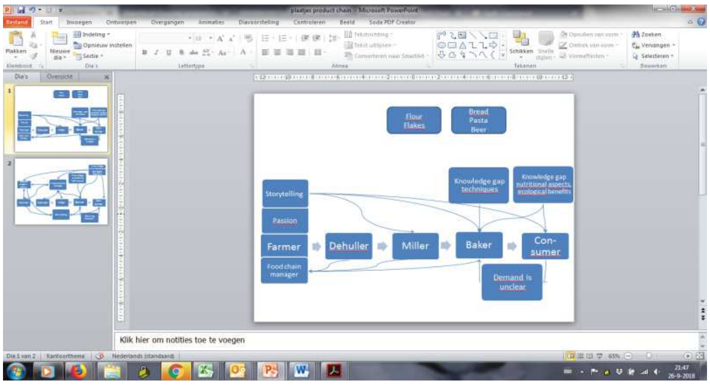

Figure 1. Schematic representation of the food chain of ancient cereals for bread making, with the identified knowledge gaps.

Conclusions and discussion

We found out that of the assessed ancient cereals, lodging tolerance (related to plant height) and yields (related to disease tolerance) were the most important agronomical traits for selection of the accessions, as these traits defined applicability in the assessed context. Furthermore, plant health and aesthetics were arguments for selection during the field meetings with stakeholders.

Some general observations are that the absence of hulls makes rivet wheat more suitable for local processing, but its tendency for lodging makes it only suitable for cultivation on real low-input soils. Emmer wheat (just as spelt) has a better lodging resistance and can be grown on somewhat richer soils and has the advantage that many consumers have heard of it. As the yields were low, it is difficult to produce einkorn, emmer and rivet on agricultural land in the Netherlands. However, we think there is an opportunity to produce them in natural areas, where there are nature goals related to arable fields. At the moment, nature reserves mostly have spelt, and rye on these arable flora fields, but einkorn and (dark) emmer can be added to the list of winter crops. Rent or land prices in nature reserved is much lower, and nature reserves could also play a role in storytelling. We identified several knowledge gaps that need attention in order to upscale local production chains with ancient cereals (Fig. 1). Information about ancient cereals (especially nutritional benefits) needs to reach consumers and bakers, in order to increase the demand.

A broker or food chain manager could play a role in knowledge dissemination, synchronise production and demand among food chain partners and logistics. Currently, the food chain manager is often the person who started an initiative. These pushers invest a lot of time in stimulating and enthusing other people. Therefore, it is important that the food chain manager is a reliable person, understanding the passion and culture of the involved food chain actors (Nuijten et al., 2017). As the product chains were small (one pallet of flour -or even less- per transportation), the logistics of the products are relatively expensive (a drawback for all small production chains). A food chain manager could be a solution to accelerate, optimise and upscale operational and logistic processes for different initiatives with ancient cereals. Furthermore, this person could build a platform for farmers and bakers and other processors (brewers, pasta makers) to find each other, inform consumers, nature organisation and bakers about the nutritional and ecological benefits of ancient cereals. At the same time more consumers should be reached to ask their baker for bread form ancient cereals (Rogosa, 2016).

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Poster in 3 min

Communication and Label Concept for Underutilized Crops: Checklist

Philipp Holzherr[1], Bernadette Oehen[2]

[1] ProSpecieRara, Switzerland, www.prospecierara.ch, philipp.holzherr@prospecierara.ch

[2] FiBL, Switzerland, www.fibl.org, bernadette.oehen@fibl.org

Key words: underutilized crops, label, marketing, communication tools

Background

As products of underutilized crops develop from small test quantities into a continuous yearly supply, sooner or later a product initiative raises the question how to best communicate the special values of these products. At this point a new label might come into consideration. However, there is more to a successful marketing strategy than the creation of a good label. New communication tools offer important opportunities, and there are several possibilities of how to make your products recognizable depending on market context.

Main chapter

During DIVERSIFOOD project ProSpecieRara and FiBL developed a framework of topics that should be taken into consideration for a new label. These topics fall into two categories: 1. Product quality and ethics of production 2. Marketing context. The former takes a rather introspecting view of a given product initiative. It analyses the special values of the promoted underutilized crops, and of their background. The goal should be to find the unique selling proposition of such products for their communication strategy. The second category takes an external view about the context in which the product initiatives operate. Target markets and target consumers are important to have in mind when eventually deciding the need for a label and in which form, and how to communicate with which tools.

The framework was identified as not only important to the target questions about communication and label. Several topics will be considered also for a marketing initiative in general. On the other hand, there cannot be given a detailed formula for the development of a successful label for all marketing contexts within countries of the European Union. The manner of good product communication depends a lot on the specific target groups. Therefore the framework was transformed into a checklist that provides a first evaluation. The checklist targets at networks of participatory breeding and community seed banks, farmers, breeders and processors of underutilized crops. It is recommended to reference at least some issues of each proposed topic. If of any one or more topics no questions can be answered, the decision for a label of underutilized crops and further steps should be reconsidered.

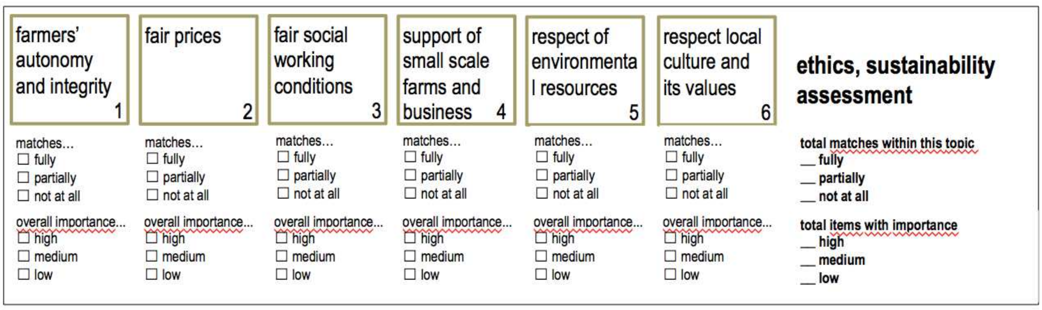

Figure 1. Checklist example of the topic "ethics and sustainability assessment"

Poster in 3 min

Peasant seeds at the test of identification signs

Frédéric Latour, Pierre Rivière, Patrick de Kochko

Réseau Semences Paysannes, France, www.semencespaysannes.org, frederic@semencespaysannes.org

Key words: common (goods), label, farmers seeds and product, mass distribution

Background

As a result of the development of peasant seeds in the fields and their recognition, the question of the economic valorization of the products resulting from the cultivated biodiversity arises more strongly within the networks of producers. Can proprietary tools such as brand and label promote this valuation?
The French Peasant Seed Network (Réseau Semences Paysannes, RSP) has been experimenting for 2 years (2016-2017) with the implementation of a collective private brand to identify products derived from peasant seeds (fruits and vegetables as a first step). In addition to value creation, this project also aimed to contribute to the legal recognition of peasant seeds in an uncertain regulatory context. This communication is a feedback on this project following a collective evaluation of this pilot phase.

Main chapter

There are currently several processes around the valorization of products derived from peasant seeds and the promotion of associated know-how which revolves around commercial brands. At first glance, the latter are indeed a relatively flexible tool, much less burdensome to implement than an official sign of quality and allowing a quick valuation for producers. As an industrial property right, its use is nonetheless neutral: the shift from a use value of peasant seeds (linked to user rights) to a market value (linked to property rights) has consequences for peasant seed systems that are fragile from the economic, organizational and legal point of view. Here are the ones that the RSP was able to observe during the two years of its collective private brand: these consequences led to the stop of the development of such a project.

1) Value capture downstream of the chain

The micro-chain of peasant varieties (short chain or specialized) are currently under tension: the volumes are very limited and we are witnessing speculative strategies generated by downstream players who aggressively invest in the organic sector. The stagnation or even the historical regression of mass distribution margins are now leading different major groups to invest the civil society to capture the value existing off market to transform it into market value. The brand, initially thought by the producers to highlight practices and take into account actual production costs (including seed conservation / selection) has proved to be a purely commercial tool from the downstream point of view. Thus, the RSP brand project was stopped by the high-profile recapture of the concept by the Carrefour group, which set up a very effective marketing campaign (the Forbidden Market), at the moment when the first products stamped by the RSP brand were going to be distributed. in a specialized organic circuit (Biocoop).

2) Difficulty generating a collective dynamic

The majority of producer organizations members of the RSP market direct sales and short local chain. They are not seeking an umpteenth quality label knowing that most are involved in other approaches (OA, Nature & Progrès, Demeter, Bio Coherence, GI, other brands ...). Thus the two collective applicants are atypical: it is two groups of vegetables growers for the long chain. In such circuits (shipping vegetables), the brand is also a tool for outsourcing the guarantee for the downstream. To put the burden of proof on the producers and their grouping is not neutral: extra cost for the producers (certification) and for the organizations (management of a brand), shift of the work factor towards the control of the guarantee and the marketing and no towards the structuring of peasant selection, risks of standardization of practices via national specifications that may lead in a loss of cultivated biodiversity.

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Poster in 3 min

The potential impact of crop species diversity on food sales in local markets

Lauri Jauhiainen and Marjo Keskitalo

Natural Resources Institute Finland (Luke), www.luke.fi, firstname.lastname@luke.fi

Key words: crop species diversity, Shannon index, economic status, municipality, local food, sales

Background

Diversification of plant production improves the resilience to climate changes. It may also increase the number of food products, especially if producers have access to the local food markets. In this research, we wanted to study the relationship between crop species diversity and the sales of selected and unprocessed food items. The overall aim is to produce more information on the reflect, which diversified plant production can induce to the local food markets through increasing the range of raw materials and products. In another hand, consumers buying local products may increase also the diversity of crop production, which is known to improve the resiliency of agriculture to changing environment.

Crop diversity and the sales of food

Nine matched pairs of municipalities were chosen so that the economic status of the pairs was the same, whereas the crop species diversity calculated by Shannon index differed. Data from the Agency of Rural Affairs (Mavi) on crops growing in Finnish field parcels was used to assess the crop species diversity within the selected municipality as described earlier (Jauhiainen & Keskitalo 2012). Three pairs of municipalities located in South Finland, and two located in each of East, West and North-Finland.

The data of the sales for 18 supermarkets located each in different municipality and forming nine matched pairs were provided by S Group statistics. S Group is a Finnish network of companies operating in the retail and service sectors, and which has more than 1,600 outlets in the country. The data, considering monthly sales during three years (2015-2017), were obtained from six food categories, such as fruits, vegetables, tuber crops, flours & starch items, flakes & grifts, and crispies & mueslis. The variance component model was applied to model how much of the variation each variable explained. The variables were: year, location (East, North, South and West-Finland), economical status of the municipality, cultivation diversity within the municipality, monthly variation of the sales, monthly variation of the sales x location interaction, monthly variation of the sales x cultivation diversity interaction, and unexplained variation.

The economy of the municipality had the strongest effect to the sales of the selected categories, describing about 52 % of the variation. But, it was interesting, that the crop species diversity had a strong effect to different categories as well. For crispies & mueslis, and fruits, the diversity explained 22,7 % and 13,7 %, respectively, of the variation observed in the sales. The diversity of crop species had the weakest effect on the sales of tuber crops, explaining only 5,2 % of the variation. The rest of the categories, vegetables, flours & starch items, and flakes & grifts, the crop diversity described 9,0 %, 6,9 % and 6,2 %, respectively, Overall, the diversity explained about 10,6 % of the variation. However, selected variables did not explain all of the variation. For crispies & mueslis, 17,5 % of the variation remained unsolved whereas the mean was about 32 % for all of the six categories.

The study showed that one the most important factor for consumers' decision making in food markets is be the economy of the municipality, which is dependent of the people's income living in the area. However, the economy may not explain everything, and other drivers exist as well. Partly surprisingly, we found, that diversity of the surrounding plant production may have an effect to food sales, especially for fresh or minor processed plant based items. This may be the consequence of improved raw material supply when the plant production is more diversified. This would mean that consumers' may have more choices to buy local food when farmers are growing different plants and crops.

The data provided by the category manager of S Group, Tiina Pensanen, is warmly acknowledged.

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Poster in 3 min

Consumer preferences for vegetables from participatory on-farm breeding networks

Claudia Meier[1], Bernadette Oehen²

[1] Research Institute for Organic Agriculture (FiBL), Switzerland, www.fibl.org/en, claudia.meier@fibl.org

[2] Research Institute for Organic Agriculture (FiBL), Switzerland, www.fibl.org/en, bernadette.oehen@fibl.org

Key words: consumer preferences, willingness to pay, farmers' varieties, participatory on-farm breeding, valorisation of agrobiodiversity, labelling

Background

The current food value chain is characterised by a highly standardised offer produced in an increasingly monotonous agricultural system. Regarding the importance of diversity for the resilience, health and productivity of a system, this development is highly alarming, both for current and future generations. To counteract this concentration process and increase the diversity of the current food value chain the approach of participatory on-farm breeding (POFB) has been proposed. Such a scheme would not only be beneficial for the environment and give farmers more independence and room for value creation but also lead to more diverse, locally adapted, healthy and tasty produce for the consumer.

Study aims

This study aimed at investigating consumer preferences for vegetables from POFB networks. This included the investigation of consumers' awareness of the problem outlined above, consumers' sympathy with the approach of POFB and consumers' willingness to pay a premium for tomato varieties from POFB networks, as marked by a label.

Method

To investigate consumer preferences for vegetables from POFB networks, we conducted a representative consumer survey in four European countries: Switzerland, Spain, Italy and France. To obtain a representative sample of the population we used the online survey method and recruited the participants through national online panel providers. In each country, a minimum sample size of n = 500 was achieved.

Results

Consumers were very interested in the seed multiplication and breeding by farmers, but showed a lower interest in more food diversity, particularly in Switzerland. However, once consumers' had been informed about the lack in diversity of the current food value chain and the potential of the POFB approach to increase its diversity, the majority of respondents liked the idea of POFB. In addition, the willingness to pay a premium was substantial in all for countries, particularly Switzerland.

Conclusion

The study shows that consumers are familiar with the topic of seed multiplication and breeding of vegetable varieties. They agree that the multiplication of seeds and the breeding of vegetable varieties should again be in the hands of farmers. This would increase farmers' independence and give them more room for innovation and value creation. On the contrary, consumers do not seem to be aware of a lack in food diversity and do not seem to make a link between food diversity and biodiversity or environmental benefits more generally.

Hence, the availability of vegetable varieties from POFB networks would respond to consumer needs. However, consumers' awareness with respect to the lack in food diversity and the link between food diversity and biodiversity should be raised in order to fully valorise the benefits of the work done by POFB networks.

The enrichment of agrobiodiversity through market valorisation strategies

Adanella Rossi[1], Gianluca Brunori[2], Bernadette Oehen[3]

[1] University of Pisa, Italy, www.unipi.it; adanella.rossi@unipi.it
[2] University of Pisa, Italy, www.unipi.it; gianluca.brunori@unipi.it
[3] Research Institute of Organic Agriculture FiBL, Switzerland, www.fibl.org; bernadette.oehen@fibl.org

Key words: agrobiodiversity enrichment, agrobiodiversity market valorisation, biodiverse products

Background

Enriching cultivated biodiversity is a necessary condition for sustainability of food systems, in terms of resilience of agroecosystems and proper diet. Re-introducing diversity in food systems - conceived as social-ecological systems, in their turn embedded in institutional-legal frameworks - is however a complex process. In that regard, the acknowledgment of agrobiodiversity multiple values (environmental, ethical and cultural), in all their manifestations, from the crop systems to the diet patterns, and the translation of this awareness in consistent practices are first crucial building blocks. They are based on the interaction among multiple actors, diversely involved in the process, each showing potentially different perspectives. In turn, these processes involve different domains, related to the technical, organisational, cultural, social, economic, institutional and juridical dimensions implicated in the reorganisation of farming systems and value chains.

The DIVERSIFOOD project focused on these various issues when investigating ways to enrich agrobiodiversity in food systems. In particular, the fifth Work Package focused on marketing strategies of food diversity, considering the appreciation of the 'biodiverse food products' in the consumption practices and thus in the market as crucial to guarantee the sustainable use of diverse genetic resources. Within it, the Sub Task 5.1.2 explored in depth the processes underlying strategies of value chain building and market valorisation for products derived from newly bred lines from participatory plant breeding, focusing on the mechanisms and dynamics developing in collectives initiatives.

Main chapter

The definition and implementation of a valorisation strategy is thus considered as a multi-actor and multi-dimensional process, based on the interactions that develop around the special values embedded in genetic resources and final products. The social learning processes that take place through these interactions are crucial to allow the actors to develop the same awareness and attitude as well as to translate these into consistent practices. These interactions develop within locally-based networks; however, the connections established among similar pathways prove to be as important to support and strengthen the mobilisation around agrobiodiversity valorisation.

The valorisation strategy has been described as composed of five areas of action, closely interdependent:

- mobilisation of genetic resources: actions aimed at knowing and managing the varieties relevant for local farming systems;
- definition of specific quality: actions to identify and codify the attributes of biodiverse products based on the selected varieties and methods of cultivation and processing;
- marketing and communication: choices and tools to manage biodiverse products in the market and convey values embodied in products and productions systems;
- integration with other projects: inter-connections with other projects/strategies, at local and broader scale;
- effectiveness and sustainability: capacity to contribute to agrobiodiversity enrichment, and to last over time.

Understanding the functioning of each stage of the valorisation process and the ways it can effectively work implies to take into consideration several dimensions: *(i)* technicalities and knowledge around the implementation of activities and processes that are completely or to a certain extent new; *(ii)* organisational issues associated with the interaction among the various actors involved; *(iii)* institutional elements mobilised to manage the various activities; *(iv)* political and legislative aspects that affect activities and processes; *(v)* social and cultural aspects involved in the several processes that take place in the valorisation strategy; *(vi)* economic conditions where the new activities and processes can work.

In the course of the DIVERSIFOOD Project, five case studies were developed, examples of valorisation strategies in different countries (France, UK and Italy). They are all marketing initiatives for bread produced using landraces, old wheat varieties or newly breed wheat varieties through participatory breeding. Despite their diversity, the case studies show relevant common features for each of the five action areas considered, but also in terms of strengths or weaknesses. They also highlight some important aspects to support production-consumption systems in their efforts to enhance agrobiodiversity. These relate to meaningful aspects in the development of marketing strategies, to policies able to create favourable conditions at farming, marketing and consumption level, as well as to the adoption of adequate research approaches to investigate the various components involved.

Session 6

Paradigm shift for muti-actor and transdisciplinary research

Keynote

A holistic multi-actor approach to agrobiodiversity enhancement

Edwin Nuijten[1], Adanella Rossi[2], Estelle Serpolay-besson[3], Véronique Chable[4]

[1] Louis Bolk Institute, the Netherlands, www.louisbolk.org, e.nuijten@louisbolk.nl

[2] University of Pisa, Italy, www.unipi.it, adanella.rossi@unipi.it

[3] ITAB, France, www.itab.com, estelle.serpolay-besson@itab.asso.fr

[4]: INRA de Rennes, France, www.rennes.inra.fr/sad-bcrp, veronique.chable@inra.fr

Key words: holistic approach, multi-actor approach, transdisciplinarity, agrobiodiversity enhancement

Background

It is now commonly acknowledged that farmers have a role in the maintenance and development of crop genetic diversity (Ceccarelli et al. 2007, Desclaux et al. 2008). There is also increasing awareness that other chain players, such as processors, traders as well as consumers have a crucial role to play (Lammerts van Bueren et al. 2018). The DIVERSIFOOD project aims to contribute to this enlargement of the circle of actors committed to increasing diversity in agri-food systems and the preservation of genetic resources. In order to do so, understanding the barriers and opportunities that affect the sustainable use of crop genetic diversity becomes crucial. DIVERSIFOOD identifies hampering and enabling factors together shaping the agri-food systems related to: 1) crop (such as breeding system, plant phenology and architecture) 2) socio-cultural aspects (labour organisation, taste preferences, learning processes and change of attitudes), 3) economic aspects (value distribution along the chain, affordability), 4) agro-ecological elements (climate, soils, farming system), 4) organisational-institutional elements (forms of coordination among actors, norms) and 5) legal-political aspects (regulatory frames, tools for genetic material protection, incentives). This wide range of aspects are moreover interconnected in complex ways. To better understand these complex interactions a holistic multi-actor approach is needed.

Main chapter

A multi-actor approach involves the various actors in agri-food systems. In order to operationalise multi-actor research DIVERSIFOOD has developed three tools: a set of key concepts expressing the shared view of the issues involved around the agrobiodiversity enhancement; a toolkit illustrating the aspects to be taken into consideration from a methodological point of view; an overarching framework integrating the various conceptual and methodological aspects involved.

In the first year, the following main key concepts were identified and developed together with all project partners: 1) diversified food system, 2) food quality, 3) sustainable food systems, 4) food democracy, 5) community management of agro-biodiversity, 6) collaborative, participative and action research, 7) trans-disciplinarity and paradigmatic shift, 8) co-evolutionary processes and 9) resilience (Collective publication 2017). In each of these key concepts various perspectives of the biological and social sciences were integrated. Together these key concepts articulate the approach adopted in the DIVERSIFOOD project, about goals and methodological choices, which help communication within the project but also with outside parties.

Secondly, a toolkit to foster multi-actor research on agrobiodiversity was developed with all partners (Serpolet et al. 2018). They were asked to describe a case study, according to a frame of research goal definition, research operationalisation and evaluation of the achievements. The partners were asked to illustrate methodology, methods and tools, and how these were connected with different knowledge fields through which actors. Through workshops important elements for conducting multi-actor research were elicited. This toolkit provides practical advice for adopting a multi-actor research approach as well as five practical examples to illustrate the variety of ways to operationalise this approach. General building blocks were identified such as common will, common vocabulary, trust, transparency, facilitation, resources and adapted distribution of the work. As the last building block shows, every multi-actor research may have its own approach adapted to the local context, because of the need to take into consideration specific crop traits, agro-ecological elements and socio-economic factors.

As a third tool, DIVERSIFOOD has developed an overarching framework to allow a better underpinning of the use of a holistic multi-actor research approach for different socio-biological contexts. This framework highlights and integrates the main components that characterise this approach. It takes into consideration: level of democracy (levels of actor involvement in the various research steps), level of trans-disciplinarity (kind of knowledge resources

mobilized and the degree of integration), multi-dimensionality (crop, technical, socio-cultural, economic, organisational-institutional, legal-political domains and associated interconnections), and reflexivity (level and modes of evaluation of achievements). By integrating these aspects, the framework allows a more informed and comprehensive implementation and monitoring of the multi-actor approach in relation to a given research question, and at the same time optimise the use of the outcomes by involved actors.

Together these three tools will help to conceptually support and to operationalise a multi-actor approach for agrobiodiversity enhancement, by positioning it into a holistic perspective taking into account all aspects and components involved in the whole food chain and by designing it consistently from a methodological point of view.

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Oral

Plant breeding as a design activity to create the plant resources for agroecology

Laurent Hazard

AGIR, Univ. Toulouse, INRA, Castanet-Tolosan, France, https://www6.toulouse.inra.fr/agir, laurent.hazard@inra.fr

Key words: Abduction, co-design, participatory plant breeding, trandisciplinarity, varieties

The challenge in agroecology is to adapt crops to a diversity of local and variable environments. Plant breeding is part of the strategy to reach this goal. However this activity has been distanced from the farm. At stake, is reconnecting breeding to agricultural practices that diversify. This issue is clearly a problem of design if we consider plant breeding as a way to design and create genetic resources for agroecology. Considering design theories may lead promising developments for innovation in the management of plant genetic ressources for agroecology.

Learning from design literature

Four important issues concerning the management of plant genetic ressources for agroecology could be drawn from the literature on design: the relationship between the artifact and its use, the relation to the existing and the degree of deconstruction, the actors involved in the design, and the knowledge management required for the process.

Relationship between the artifact and its use

Incremental design (Fig 1) consists in creating new functions for, or improving the functions of, an existing artifact (Braha and Maimon 1997). Another common strategy is 'technology push', which corresponds to the technology transfer model: scientific advances are transformed into new artifacts that are then developed and disseminated. Their use is not explicitly taken into consideration. 'Demand pull' reverses the process: in this case, use creates a need and tests the designers' creativity in creating the expected artifacts.

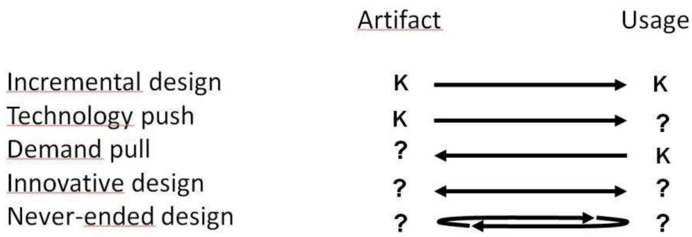

Fig 1: Design strategies linking the artifact to be created to its usage according to the designers' knowledge (K) of them

Innovative design, for which neither artifact nor its use is clearly defined, is seldom used in plant breeding. The work then focuses on the creation of a new artifact for a new use (Braha and Maimon 1997). In activity theory, the separation between design and use is simply a state of mind: design continues during use (Simon 1969). The user transforms the designed artifacts or diverts them from their intended use. That is the case when a livestock farmer decides to have his livestock graze a cereal variety that was originally bred for grain (Latta 2015). Karasti (2014) speaks of continuing design, in which the boundaries between use, design, implementation, modification, maintenance, and redesign are blurred. Perpetuating the instability between artifacts and uses results in never-ending design. This has been the case of mass selection by farmers since the Neolithic, when the process of co-evolution between plants and their uses began.

Level of deconstruction

Design thus swings between tradition (i.e., improving the existing) and what Ehn (1988) calls "transcendence" (i.e., exploring possibilities outside the current paradigm). The level of transcendence reached by designers depends on their creativity when transforming and reducing the problem to a treatable question: will they select for a plant that is more resistant to drought or design tools to help farmers find their own solutions to their drought problem? This framing depends on how the need is expressed, on the designers' professional environment, on their level of specialization, their skills, and also on what they value in their activity.

Participants in the design

Today, the linear view of design still prevails connecting three stages: the space of the intellectual creation of the artifact, the workshop in which it is assembled and produced, and the space of its use and consumption (Fig. 2).

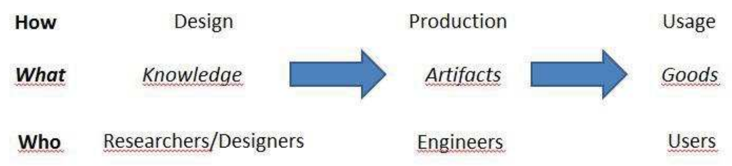

Fig 2: The linear view of design to be challenged

In the 1970s, it appears that the chances of producing artifacts that are used increase with dialogue and feedback from engineers and users (Waks 2001); moreover, since innovation changes our lives, citizens should be consulted to direct innovation towards building the world they want. Breaching linearity defines different types of participatory design depending on the role played by the non-professional designers in the process ranging from consumers' consultation in the "demand-pull strategy" (Cooper, 2004) to co-design where actors are deeply involved all stages: defining the end, choosing the means, participating in the creative work, prototyping, testing, etc. (Buur and Matthews 2008).

Knowledge management

The artifact to be designed does not present itself neatly as a case to which a scientific discipline can apply scientific generalizations (Waks 2001). Even technology push, based on scientific knowledge, requires other types of knowledge to complete a successful artifact. Design is a transdisciplinary approach, which, according to Max-Neef (2005), connects knowledge and values. However, as pointed out by Max-Neef (2005) "we know very much, but understand very little", "understanding" here meaning the capacity to act. Clearly, the additional knowledge of practitioners and the mutual understanding of each other's point of view significantly improves the quality, acceptance, and sustainability of designed artifacts. If scientists and practitioners are key sources of knowledge, non-experts are also able to participate in the production of knowledge, especially since it arises from a concrete task; i.e. creating an artifact. Actors' involvement in knowledge production depends on the design approach: it ranges from being the subject of knowledge extraction using ethnographic methods to supply scientific modeling, to their participation to the co-production of new mental models, new meanings, and new situations of use that characterize co-design.

Conclusion

Considering design litterature showed that designing plant resources for agroecology needs to exploit co-evolution of cultivated plant and farming practices to better match genetic innovation and use. However, this challenges the current regime of genetic innovation based on a static view of a plant variety. Thinking out of the box, the challenge is to foster creativity at all stages of the design: problem framing, problem solving and solution implementation. This activity should be extended to include farmers and their advisors to promote the suitability and encourage acceptance of the designed resources. What is more, their participation as co-designers enables learning by doing in real-size tests. The process can be managed as a pragmatist collective inquiry (Metcalfe 2008). To be part of it, researchers should shift from a prescriptive to an interpretative stance. Considering plant breeding as a co-design rather than a technology-push activity opens new avenues to develop genetic resources for agroecology.

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Poster in 3 min

NOVIC: A Participatory Project to Trial and Breed Vegetable Varieties for Organic Systems

Jim Myers[1], Bill Tracy[2], Micaela Colley[3], Michael Mazourek[4]

[1] Oregon State University, United States, http://horticulture.oregonstate.edu/content/jim-myers, james.myers@oregonstate.edu
[2] University of Wisconsin-Madison, United States, https://agronomy.wisc.edu/bill-tracy/, wftracy@wisc.edu
[3] Organic Seed Alliance, United States, www.seedalliance.org, micaela@seedalliance.org
[4] Cornell University, United States, https://hort.cals.cornell.edu/people/michael-mazourek, mm284@cornell.edu

Key words: Organic, Participatory Plant Breeding, Breeding for organic systems

Background

Organic production is rapidly growing, but growers lack access to certified-organic seed and vegetable varieties adapted to organic production. Most available varieties have been bred in and for conventional production systems. An organic system is a different growing environment from conventional systems, and for optimal productivity, a variety should be adapted to the target environment. To obtain optimally adapted varieties, one needs to breed in the target environment. Organic growers can increase their market share with improved varieties that are adapted specifically to organic systems and meet the needs for disease resistance, nutritional and flavour quality, and contemporary productivity traits crucial to modern markets.

Main chapter

The overall goal of the Northern Organic Vegetable Improvement Collaborative (NOVIC) project is to increase the proportion of U.S. agriculture that is managed organically. Now in its seventh year, the NOVIC project seeks to achieve this goal by increasing the number of vegetable varieties tailored to organic systems, and available as organic seed. NOVIC is a joint collaborative project of Oregon State University, University of Wisconsin-Madison, Cornell University, Organic Seed Alliance, United States Department of Agriculture Agricultural Research Service and Plant Genetic Resources Research, and over 30 organic farms in Oregon, Washington, Wisconsin, and New York.

NOVIC is developing new vegetable varieties for organic agriculture. Organic systems represent an agroecological environment different from conventional systems. Due to significant genotype by system interaction, varieties intended for organic production should be bred in those conditions for optimal performance and adaptation. This project uses the participatory plant breeding model to develop open-pollinated varieties adapted to meet the needs of organic growers.

NOVIC is conducting variety trials with farmers in real-world conditions. The project team identifies commercial cultivars and new breeding lines that are productive, stable, and resilient in organic systems. These breeding lines are continually tested in the divers, real-world environments of our farmer partners in each region.

NOVIC is improving the availability of farmers and seed producers to grow organic seed. Project partners host variety trial field days and in-depth participatory plant breeding workshops to engage and empower organic producers with skills and information. In partnership with eOrganic, the project group maintains a database of published organic variety trial results. The team also publishes on project outcomes to a variety of audiences, including growers, seed companies, regulators, academic peers, and a general audience.

Figure 1: NOVIC project reach

Poster in 3 min

Participatory ideotyping for organic and locally adapted wheat variety mixtures

Emma Forst[1], Jérôme Enjalbert[1], Julie Borg[1], Arnaud Gauffreteau[2], Bastien Paix[3] and Isabelle Goldringer[1]

[1] Génétique Quantitative et Evolution - Le Moulon, France, moulon.inra.fr/, emma.forst@inra.fr

[2] Agronomie, France, www6.versailles-grignon.inra.fr/agronomie

[3] Groupement d'Agriculteurs Biologiques d'Ile-de-France, France, www.bioiledefrance.fr/

Key words: variety mixture, wheat, organic farming, ideotyping, assembly rules, co-design

Background

There are major challenges in agriculture, particularly in organic systems, such as stabilizing production in the face of increasing environmental heterogeneity and reducing input use. Nevertheless, very few varieties are adapted to organic farming. Increasing within-field diversity, especially by growing variety mixtures, may allow to buffer abiotic stresses, stabilize productions (Ostergaard et al 2005), regulate pests and foliar diseases (Finckh et al 2000),improve weeds control, and optimize the use of resources due to compensation and complementarity between varieties.

In the case of wheat, mixture components have been assembled primarily on the basis of their yield, their complementarity for disease resistances and to maintain homogeneity for height and maturity. However, other criteria of interest for plant interactions such as earliness should be considered to design mixtures, but very few is known about plant interactions within mixtures. We aimed to optimize the design of variety mixtures using relevant criteria and integrating farmers' practices and objectives for production, therefore allowing to finely tune mixtures to local production contexts (Barot et al 2017).

Main chapter

In order to develop mixtures adapted to various terroirs and practices, it has been proposed to identify assembly rules of varieties in mixture ideotypes to guide farmers when designing mixtures. Thus, participatory ideotyping was suggested as particularly suitable for designing locally adapted mixtures (Wheatamix, https://www6.inra.fr/wheatamix/). Here, we have adapted this approach to the context of organic farming with a group of seven organic farmers from the Ile-de-France region (GAB IdF) (Fig.1).

i) Interviews have been conducted with the farmers to describe their production systems and their practices and requirements for wheat production.

ii) Workshops were held with farmers, technicians and researchers to define assembly rules describing the traits to combine in a mixture (based on morphological, phenological, physiological characteristics and disease resistances) to buffer specific stresses or optimize resource use, by mobilizing complementarity or synergy mechanisms.

iii) Then farmers' wheat mixtures have been co-designed based on the assembly rules relevant to their context, the characteristics of varieties bred for organic farming and their practices.

iv) These mixtures were evaluated on-farm in a strip experiment allowing for comparison between the mixtures and the corresponding varieties in pure stands. They were assessed for two growing seasons (2015-2016 and 2016-2017) on yield, quality, competition against weeds, development of foliar diseases and on their adequacy to the farmers' specific objectives.

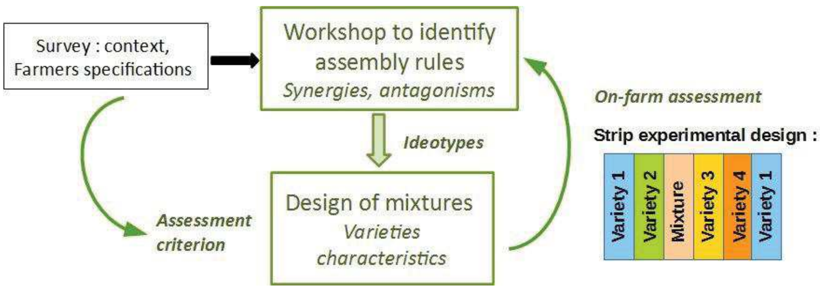

Figure 1. The ideotyping approach

The two-year on-farm agronomical assessment of these designed mixtures confirmed the interest of mixtures (+7% for yield and stable protein content), especially in stressing conditions such as in organic systems.

Poster in 3 min

Seeding the Green Future – Participatory organic cotton breeding

Monika M. Messmer[1]; Shivraj Raghuwanshi[2]; Ramprasad Sana[3,4]; Rajeev Verma[5]; Tanay Joshi[1]; Sunil Jain[6]; Rashid Sheikh[6]; Arun Ambatipudi[3]; Amritbir Riar[1]

[1] Research Institute of Organic Agriculture (FiBL), Switzerland, www.fibl.org, monika.messmer@fibl.org, tanay.joshi@fibl.org; amritbir.riar@fibl.org
[2] Pratibha Syntex Ltd, Indore, India, www.pratibhasyntex.com, ssr.abm@gmail.com
[3] Chetna Organic, Hyderabad, India, www.chetnaorganic.org.in, arun.ambatipudi@chetnaorganic.org.in
[4] Centre for Sustainable Agriculture, CSA, Secunderabad, India, www.csa-india.org, ramprasad@csa-india.org
[5] CottonConnect , Gurgaon, India, cottonconnect.org, rajeev.verma@cottonconnect.org
[6] Action for Social Advancement, ASA, Bhopal, India, www.asaindia.org, sunil@asabhopal.org, am-petlawad@asabhopal.org

Key words: organic cotton, participatory breeding, capacity building, *Gossypium arboretum, Gossypium hirsutum*

Background

There is a growing demand of consumers for organic textiles. India is the most important country for the global organic cotton production with 67% market share challenged by 95% genetically modified (GM) cotton cultivation in India. Fast action is needed to maintain non-GM cotton germplasm for organic farmers. Participatory breeding of *Gossypium hirsutum* and traditional *G. arboreum* cotton offers a great opportunity for developing locally adapted cultivars and increasing genetic diversity. Seeding the Green Future funded by Mercator foundation Switzerland and Organic Cotton Accelerator will build on achievements of Green Cotton Project phase I (www.greencotton.org, Messmer et al. 2017). The overall goal is to upscale local capacity building in breeding and seed multiplication to improve autonomy and income security of farmers. The objectives are to (i) initiate and scale up decentralized breeding efforts from crosses to final cultivar development in different States, (ii) coordinate organic cultivar testing, multi-location trials under different management and at different farmers associations, (iii) broaden the genetic diversity and encounter challenges of climate change by promotion of traditional drought tolerant *G. arboreum*, (iv) involve farmers in breeding, selection and seed multiplication, (v) intensify networking and exchange between public and private stakeholders, (vi) disseminate results among organic cotton growers, the textile industry, and the scientific community, and (vii) create awareness for benefits of organic cotton among consumers.

Main chapter

Due to the pressing need of adapted non-GM cotton seed, an enlarged consortium with organic cotton growers and public institutes from different regions came together to join forces in 2017. During two workshops common goals were defined as well as a code of conduct for sharing genetic material. To scale up the project, different tasks were divided between partners. The more advanced organisations invest in the establishment of on-station replicated field trials on their farm, while other organisations were more interesting in testing promising material in a large range of environments using their farmer networks. A local facilitator was installed to coordinate the different activities and the timely implementation of the project. The project is outlined for two 4-year periods to achieve potential cotton candidates for cultivar release. Thirty non-GM cotton cultivars and breeding lines adapted to the Central cotton zone were collected from different States, tested for contamination with GM and for fibre quality. A core set of cotton genotypes meeting the minimum requirements were tested in replicated field trials at organic farmers' organisations at four sites in Odisha and Madhya Pradesh complemented by local cultivars. The most promising cultivars identified during the Green Cotton project were tested in on-farm trials in farmers' fields including commercial hybrids, inbred lines as well as *G. arboreum*. In order to increase genetic diversity and combine high fibre quality with agronomic performance and local adaptation new crossed were made among the *G. hirsutum* and *G. arboreum* germplasm. Segregating populations from the previous projects were advanced from F2 to F4 generations. Farmers were engaged not only in the on-farm trials but also in workshops and active selection of the on-station cultivar trials. Special focus were given to the involvement of female farmers and Indian tribes with marginal growing conditions. Opportunities and challenges of local capacity building in breeding and seed multiplication will be discussed including socio-economic aspects. The project is open to involve more farmers associations and serves as model to safeguard organic cotton seed on global scale.

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Poster in 3 min

LIVESEED boosting organic seed and plant breeding across Europe

Monika M. Messmer[1]; Freya Schäfer[2]; Maaike Raaijmakers[3]; Frédéric Rey[4]; Véronique Chable[5]; Edwin Nuijten[6]; Edith Lammerts van Bueren[6]; Pedro Mendes-Moreira[7]; Riccardo Bocci[8]; Dora Drexler[9]; Susanne Padel[10]; Raffaele Zanoli[11]; Alexandra Fuss[12]; Bram Moeskops[12]

[1] Research Institute of Organic Agriculture, FiBL Switzerland, www.fibl.org, monika.messmer@fibl.org
[2] Research Institute of Organic Agriculture, FiBL Germany, www.fibl.org, freya.schaefer@fibl.org
[3] Bionext, The Netherlands, www.bionext.nl, Raaijmakers@bionext.nl
[4] Institut Technique de l'Agriculture Biologique. ITAB, France, www.itab.asso.fr, Frederic.rey@itab.asso.fr
[5] INRA de Rennes, France, www.rennes.inra.fr/sad-bcrp, veronique.chable@inra.fr
[6] Louis Bolk Institute, LBI, The Netherlands, www.louisbolk.org, e.nuijten@louisbolk.nl, E.Lammerts@louisbolk.nl
[7] Instituto Politécnico de Coimbra – Escola Superior Agrária de Coimbra, Portugal, pmm@esac.pt
[8] Rete Semi Rurali, RSR, Italy, www.semirurali.net, riccardo.bocci@semirurali.net
[9] Hungarian Research Institute of Organic Agriculture, ÖMKi, Hungary, www.biokutatas.hu, dora.drexler@biokutatas.hu
[10] Organic Research Center, ORC, The United Kingdom, www.organicresearchcentre.com, susanne.p@organicresearchcentre.com
[11] Università Politecnica delle Marche, Italy, www.univpm.it, zanoli@agrecon.univpm.it
[12] IFOAM EU Group, Belgium, www.ifoam-eu.org., alexandra.fuss@ifoam-eu.org, bram.moeskops@ifoam-eu.org

Key words: organic seed, organic breeding, seed health, networks, organic regulation, seed supply chain

Abstract

The European project LIVESEED (www.liveseed.eu) is based on the concept that cultivars adapted to organic systems are key for realizing the full potential of organic agriculture in Europe. LIVESEED will help to establish a level playing field in the organic seed market across Europe, improve the competitiveness of the organic seed and breeding sector, and encourage greater use of organic seeds by farmers. LIVESEED will improve guidelines for cultivar testing and strategies for ensuring seed health. It will develop innovative breeding approaches suited to organic farming. Finally, it will investigate socio-economic aspects relating to the use and production of organic seed and their interaction with relevant (EU) regulations. The LIVESEED project (2017 – 2021) is coordinated by IFOAM EU with FiBL for scientific coordination and consists of 35 partners and 14 third linked parties from 18 European countries. LIVESEED received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727230 and by the Swiss State Secretariat for Education, Research and Innovation (SERI) under contract number 17.00090.

By connecting several networks LIVESEED will combine co-construction and exchange of knowledge integrating biological, technical, legal, organisational, financial and political aspects as well as market development to facilitate fast upscaling and outreach of various tailor -made socio-technical, evidence based, innovation tracks. LIVESEED will generate (i) a tool box of measures and interventions to match production and demand of organic seed, (ii) validated options for competent authorities to reduce the number of derogation for untreated conventional seed, (iii) develop technical solutions for national databases of organic seed including an interface to a European wide router database to increase the transparency on the availability of organic seed, (iv) analyse in depth formal and informal seed chains, (v) explore various business models including checklists for setting up new multiplication and breeding initiatives, (vi) produce technical factsheet on the best practice guidelines for seed production for major crops including vegetative plant propagation material, and (vii) an develop organic seed quality strategy including quality control of farm saved seeds and efficiency of seed exchange networks.

With respect to organic plant breeding LIVESEED will provide new concepts for designing and implementing decentralized breeding initiatives for organic and low-input agriculture through (i) establishing networks across Europe (e.g. for apple, brassica vegetables) and fostering public-private partnerships, (ii) combining farmer, value chain or community based system breeding with functional trait-based and molecular breeding approaches, (iii) identifying trade-offs between resilience traits and sensory and nutritional quality, (iv) developing breeding schemes for heterogeneous cultivars and species mixtures, and (v) elaborating different financing models. Considering the plant as a mega organism, including the above and below ground associated microorganism, has the potential to evoke a paradigm shift in plant breeding, and will be elucidated in case studies.

Poster in 3 min

A paradigm shift for muti-actor and transdisciplinary research

Véronique Chable[1], Edwin Nuitjen[2], Adanella Rossi[3]

[1] INRA Bretagne-Normandie, France, www6.rennes.inra.fr/bagap, veronique.chable@inra.fr
[2] Louis Bolk Institute, The Netherlands, www.louisbolk.org, e.nuijten@louisbolk.nl
[3] University of Pisa, Italy, www.unipi.it, adanella.rossi@unipi.it

Key words: paradigm, multi-actor, diversity, participatory research, organic agriculture,

Background

A paradigm shift refers to a radical change in beliefs or theory. DIVERSIFOOD has established diversity as the foundation of resilient food systems working with the hypothesis "the whole is greater than the sum of the parts".

Main chapter

A new paradigm is called for after one century of standardisation in the agro-food system

"From uniformity to diversity: a paradigm shift from industrial agriculture to diversified agroecological systems" is the title of the report of the International Panel of Experts on Sustainable Food systems (IPS-Food 2016). DIVERSIFOOD witnesses experiences from the ground to design more precisely this paradigm shift and to provide elements to involve a large community - from research to market – in redefining food chain organisations based on a holistic knowledge of living processes involved in resilience.

Diversity and living processes

Uniformity invading all levels of modern societies has covered the overall food production and has broken the intrinsic link of agriculture with the living systems. At the other end of the food chain, most of consumers have no more idea of the farming realities, of the needs of their own body and of the quality of their food.

DIVERSIFOOD is deeply influenced by the messages of pioneers of organic agriculture as Sir Albert Howard (1943) who pointed out the close connexions between health of soil, plants, animals and humans, meaning all living beings are interdependent. According to this vision, alternative food systems should be conceived through the holistic approach. Indeed, the new paradigm addresses all the practices from farming to food processing, distribution and consumption. DIVERSIFOOD promotes organic farming and agroecological farming systems based on diversity and respect of biological processes and societal needs (or, in other words, based on living systems). To do that, DIVERSIFOOD engages in recovering and enriching crop diversity by reintroducing underutilised and forgotten species, adopts multi-actor and participatory plant breeding methods to increase diversity and the capacity to manage it, promotes community agrobiodiversity management to empower local farming systems and collective approaches, and explores the conditions to create sustainable local markets able to appreciate diverse products.

Widespread diversity for a full resilience

DIVERSIFOOD has established all its actions and studies within this "life-oriented" paradigm to boost diversity at all levels, exploring crop and food system diversity, considering different sources of knowledge equally and sharing them, integrating objectives for environmental and social sustainability within a holistic perspective. Alternative and resilient food systems should cover at the same time food production through sustainable systems, and local and global conditions of food democracy and community involvement in biodiversity management (Booklet 9 key concepts).

A research commitment to a life-oriented approach

In a perspective putting "Life" - all living systems in all their manifestations - first, DIVERSIFOOD has promoted collaborative, participative and multi-actor research and had adopted trans-disciplinarity. Whilst the formal seed sector have stored the living diversity from landraces as genetic resources in genebanks for one century, DIVERSIFOOD has brought to light the neglected diversity of several underutilised and forgotten species (IF #4) and has evaluated it within networks of farmers in different agro-ecosystems in Europe. DIVERSIFOOD has tested new breeding strategies (IF #2 and 11) with farmers to renew and increase cultivated diversity. DIVERSIFOOD has described and created links between Community Seed Banks in Europe (IF #1), shedding light on these informal seed systems that manage their seeds following common objectives based on shared values, knowledge and collective rules, developing awareness and a specific identity. DIVERSIFOOD has explored the multi-dimensional aspects associated with diverse food marketing approaches, and studied consumers' behaviours about diversity, labelling concepts (IF #8) and new local markets with diversified products.

Promoting diversity to promote the harmonic reorganisation around life values

The fact that the choice of seed determines farming practices and then all the steps of the food chain until the plate of the consumers, reinforces the initial idea of DIVERSIFOOD: "to provide an alternative food culture". The scientific hypotheses, mainly based on genetics for modern plant breeding, are completely revisited and enlarged when we breed for resilience and adaptation of social-ecological systems. As Howard observed, in organic farming all living beings are linked and evolving together: plant populations bred and multiplied on farm allow an authentic organic agriculture to progress toward resilience. Meanwhile, diversified food should stimulate a renewal of food culture, providing an alternative to the standardizing trend of the dominant food supply, helping citizens to connect their existence and wellbeing with the health of the planet.

Renewing organic foundations to redesign our future

Adopting a life-oriented paradigm is instrumental also to renew the current foundations of organics. The word "life" is the cornerstone of the paradigm shift, as it is for the organic movements. This qualitative paradigm shift could help to promote a radical redefinition of the dominant socio-technical systems in which they operate. All this seems to show a significant potential for a renewed, sustainable co-evolution of socio-economic and ecological systems.

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Session 7

Closing session - toward a socio-ecological transition: Diversifood message for the future

Keynote speaker « Grand témoin » of the congress

The Landscape of Organic and Ecological Seed, a US perspective

Micaela Ruth Colley[1]

[1] Organic Seed Alliance, United States, www.seedalliance.org, micaela@seedalliance.org.

Key words: organic plant breeding, variety trials, organic seed, participatory plant breeding, seed diversity

Background

Over the past few decades, the important role of seed in organic and agro-ecological systems has gained more awareness and momentum in the US and Europe. During this time the seed movement grew from a grassroots initiative into an established sector of research and industry. The movement is driven by goals of reinvigorating crop genetic diversity and healthy agro-ecosystems in part as a response to trends that include the loss of crop genetic diversity, extreme seed industry consolidation, and excessive use of restrictive intellectual property rights (Khoury et al. 2014, Howard 2015). Expansion of organic seed initiatives is further motivated by the implementation of the organic seed regulation by the USDA National Organic Program (NOP) and the European Union in the early 21st century (USDA-NOP 2002). The organic sector is both an important stakeholder and actor in developing ecological and diverse seed systems since organic farming emphasizes cultural management techniques, including choosing crop genetics to mitigate production challenges. Furthermore, the organic sector philosophically values the important role of diversity in the sustainability of agricultural ecosystems.

Seed systems in the United States and Europe

Many parallels exist between the United States (US) and Europe regarding the timing, motivations, and emerging models for developing organic seed systems. However, the two geographic regions are influenced by important differences in the context of governance, history, and social factors impacting progress. For example, the US, unlike Europe, does not have a formal, governmental seed registry system. The absence of a required seed registry allows farmer-breeders and smaller seed companies in the US to commercialize genetically diverse varieties that may lack rigorous phenotypic uniformity. While recent exceptions for conservation of heirlooms has increased flexibility in the European system, there is still greater freedom in the US for growers to practice on-farm seed saving and to commercialize a greater diversity of seed. At the same time, the lack of a registry system limits US efforts to track crop genetic diversity and organic seed availability. In the US, organic producers and seed companies, unlike their European counterparts, also grapple with cross contamination from genetically modified crops not allowed in organic systems. Farmers across the US are forming networks to exchange knowledge and share germplasm as they work to regain seed sovereignty on their farms, an act more challenging to develop in Europe where language barriers often inhibit communication across borders. Both regions face common, global issues regarding the impacts of consolidation in the seed industry, which has led to less genetic diversity in commercial crops and a greater dependence on the decisions of fewer breeders (Howard, 2015). Although barriers to fostering seed diversity exist, we must also celebrate and nurture our accomplishments. Following are a few promising trends emerging across the US landscape shared from the perspective of Organic Seed Alliance (OSA), a US non-governmental organization with the mission of advancing ethical seed solutions to meet food and farming needs in a changing world (www.seedalliance.org).

State of Organic Seed in the US

Each year OSA educates thousands of farmers and other agricultural community members, conducts professional organic plant breeding and seed production research, and advocates for national policies that strengthen organic seed systems. OSA does not do this work alone. A growing network of educators, researchers, advocacy groups, and seed and food industry members are aligning to focus on fostering the diversity, ecology, and integrity of organic seed systems. Every five years OSA releases the *State of Organic Seed* report as part of an ongoing project to monitor the status of organic seed nationally and provide a roadmap for increasing the diversity, quality, and integrity of organic seed available to US farmers. According to the most recent (2016) report, organic farmers are using more organic seed than 5 years ago. Across all crops organic farmers surveyed reported planting an average of 69% of their acreage to organic seed, up 11% from 2011 (Figure 1). The percentage, however, varies by crop type with a slightly lower percentage in field crops compared to vegetable and grain crops. The report also found that as the size of vegetable operations increase, the percentage of acreage planted to organic seed decreases. Organic farmers however reported greater satisfaction with organic seed responding that quality issues were on par with conventional (non-organic) seed. They also recognized the importance of organic seed in the integrity of organic foods and 60% of farmers responding are already saving seed for their own on-farm use and/or for commercial sale. (Hubbard and Zystro 2016).

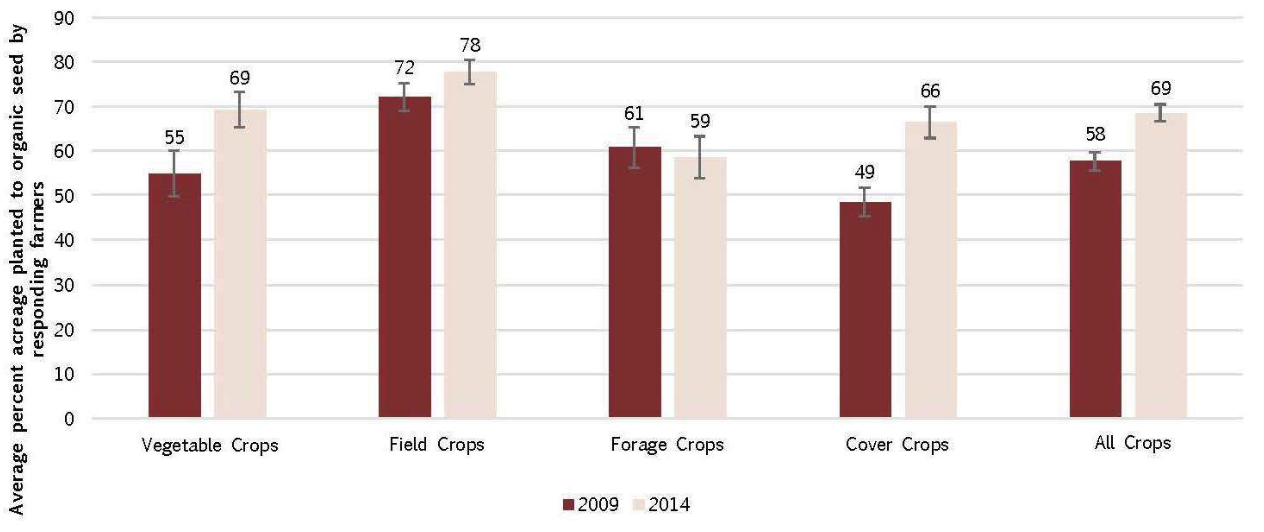

Figure 1. Average percent acreage planted to organic seed by responding farmers, *State of Organic Seed*, 2016.

State of Organic Seed also tracks investments in public organic plant breeding and other organic seed research, including an assessment of challenges, impacts and outcomes. Public and private investments in organic plant breeding and seed research in the US grew by more than $22 million over the last five years alone, compared to $9 million invested between 1996 - 2009 (Hubbard & Zystro 2016). The USDA's Organic Research and Extension Initiative (OREI) represented the largest contributor along with other government programs and private foundation. While this level of funding still pales in comparison to research investments focused on non-organic systems, it represents much progress in supporting organic seed initiatives across the US, including the work of OSA. Congress appropriates OREI funding in the farm bill, which is typically renewed every five years. 2018 is a farm bill year and many organic advocacy groups are lobbying hard for increased support of this and other sustainable agriculture programs, but the dependence on this single program underscores the fragility of many organic seed initiatives.

Growth in public organic plant breeding research

One of the most promising shifts over the past decade is growth in organic plant breeding in universities across the US. Supported by public and private investments, these programs are generating a new wave of graduate students entering the job market with training in organic plant breeding. Two universities now hold endowed chairs in organic plant breeding, including Dr. Stephen Jones at Washington State University and Dr. Bill Tracy at the University of Wisconsin-Madison. Clif Bar & Company funds these two positions thanks to matching funds from the organic food industry. The Clif Bar Family Foundation has additionally supported 16 graduate student fellowships since 2011. These graduate students are helping to build the body of scientific literature on organic plant breeding and carving professional paths in this sector as well. In 2012, a group of students launched the Student Organic Seed Symposium (SOSS) to create an annual gathering of students, professors, and members of the broader organic seed community to share research, learn about the burgeoning organic seed community and trade, and network with members within it. In 2016, SOSS launched the Society of Organic Seed Professionals (SOSP) to create a professional space outside of the symposium for organic seed students, researchers, and others (Luby et al. 2013).

Variety trial networks

Organic variety trial networks are expanding across the US, fostering the exchange of knowledge on variety performance under organic farming conditions to inform breeding needs and support the adoption of organic seed. Examples include the Northern Organic Vegetable Improvement Collaborative (NOVIC), the University of Wisconsin-Madison's Seed to Kitchen Collaborative, the Eastern Sustainable and Organic Cucurbit project, the US Testing Network, of Practical Farmers of Iowa and many others. These networks are developing robust research methods while also leveraging on-farm testing and farmer-chef participation in variety evaluations. A new initiative is underway to develop a national organic variety trial network, led by Dr. Julie Dawson, University of Wisconsin-Madison and OSA (Dawson et al. 2017). This group aims to develop common testing protocols and a central database for collecting, sharing, and evaluating findings. The goal is to coordinate trials across the country under diverse regional environments both on farms and at research stations. The trial network includes university breeders, organic seed companies, and farmer-breeders. Several online tools are supporting

trial efforts and providing platforms for sharing results. Two examples are the organic variety trial database, a repository for accessing reports of trial results nationally, and the online variety trial analysis tool, a farmer-friendly resource for analysing trial results statistically, generating tables, and sharing results. (https://varietytrials.eorganic.info; https://organicseed.shinyapps.io/OrganicTrials/).

Participatory plant breeding

Participatory plant breeding (PPB) has taken hold in the US as a commonly employed model in organic plant breeding. The value of involving farmers in organic plant breeding is arguable for biological, cultural, and economic reasons. PPB leverages a low economic barrier to entry, the selection of genetics within the environment of intended use, and the engagement of stakeholders in the breeding process (Shelton & Tracy 2014). Farmer-bred and participatory-bred varieties are now touted in several regional and national seed catalogues, including Southern Exposure Seed Exchange, Adaptive Seeds, High Mowing Organic Seeds (HMOS), Territorial Seeds, and Johnny's Selected Seeds. For example, in 2014 HMOS released an open-pollinated SE sweet corn variety called 'Who Gets Kissed?' The variety is the result of a partnership between OSA, University of Wisconsin-Madison, and sweet corn farmer Martin Diffley (Shelton & Tracy 2015). The story of the variety's genesis was promoted by the seed company and breeding partners, and the variety held the highest grossing sales in the first year of any new variety release in the history of the company. Many participatory breeding projects involve multiple farmers within a region or exchanges of seed and testing in other regions. This networked approach to breeding and variety trials generates off shoots of additional organic variety development efforts. For example, and organic broccoli effort of NOVIC started with a highly diverse breeding pool and then conducted on-farm selection on 14 farms over 6 years with annual re-distribution by Dr. Myers in Oregon. The project, spread to additional farms in other regions across the US through trial networks and seed exchanges. Over a 10-year period, the project generated at least 4 new cultivars or populations that were either commercialized or used on farms in diverse geographic environments.

Farmers across the US are coming together to share breeding experiences through various forums. Conferences, on-farm plant breeding workshops, farmer-to-farmer networks, and social media platforms are fostering the exchange of plant breeding knowledge and germplasm. The biennial Organic Seed Growers Conference convenes over 400 participants to share organic seed and plant breeding research, deliver trainings and host field tours, and an additional 300 participants typically engage with the conference through an online interface with the event. The 10th Organic Seed Growers Conference is set for February 2020 in Corvallis, Oregon. NOVIC is an example of growth in on-farm organic plant breeding workshops reaching over 200 farmers in 8 states over the past 8 years. The Farm Breeding Club of the Northern Plains Sustainable Agriculture Society is another example of participatory breeding where a group of farmers and researchers collaborate on regional organic breeding projects with the goal of releasing new varieties. Website and social media platforms are also emerging to support the exchange of knowledge, such as the facebook groups "Squash Party", "Northern California Plant Breeding Club", and the "Breeding for Permaculture". Events and networks like these are empowering more farmer-breeders to initiate on-farm projects.

Intellectual property rights continue to be both a challenge and opportunity for public breeders and farmer breeders alike striving to recoup royalties to invest in their programs while avoiding the use of patents and protecting their varieties and plant genetic resources from the patenting of private industry. Seeds and Breeds for 21st Century Agriculture is a coalition of public plant breeders and other researchers, policy advocates, seed companies, and other stakeholders who are committed to finding solutions for reinvigorating public plant breeding, including addressing the impacts of overly restrictive intellectual property practices. This group has convened four summits to provide a forum for building strategies to advance public plant and animal breeding programs, with the last summit held in 2014 (Tracy and Sligh, 2014).

Several PPB and famer-bred varieties are now commercially available and several are registered with the Open Source Seed Initiative (OSSI). OSSI is a non-profit organization that has developed a pledge system for seed releases. Originally OSSI set out to create an open-source license, in line with other seed licensing agreements, with the goal of protecting genetic resources from patents and other restrictive forms of intellectual property. After much effort, the license approach proved unfeasible, and in the end the group decided to abandon traditional intellectual property tools and instead create a pledge that aims to serve as a social contract between breeders and other growers, researchers, and businesses. The pledge reads that, "You have the freedom to use these OSSI-Pledged seeds in any way you choose. In return, you pledge not to restrict others' use of these seeds or their derivatives by patents or other means, and to include this Pledge with any transfer of these seeds or their derivatives." OSSI has raised awareness about the importance of keeping seed in the public domain, and continues to provide a platform for denouncing patents and other restrictive forms of intellectual property. The initiative underscores the importance of farmer-breeders rights, but it is challenged by the inability to contain seed and genetics to ensure all recipients comply with the pledge particularly within a sector striving to foster free exchange within informal seed systems.

Expanding the seed community – multi-actor approaches taking hold

The organic seed sector is quickly expanding to include other meaningful actors. Chefs, food businesses, and eaters are gaining awareness of the importance of having access to seed that reflects their values and wishes: healthy ecology, diversity of choice, and superior culinary qualities. The full supply chain is not yet engaged, but several inspiring initiatives show promising trends and are gaining prominence in the media. The Culinary Breeding Network (CBN) catapulted onto the food scene in 2012, uniting chefs and plant breeders to co-explore the culinary potential of plant breeding. They come together each year to showcase new varieties in chef-inspired dishes and variety tastings at the annual CBN Variety Showcase (culinarybreedingnetwork.org). Now in its 6th year, the event has grown from a Portland, Oregon, gathering of about 100 chefs, plant breeders, and food enthusiasts to an event prominent in the press, attracting 540 participants in 2017 with plans underway for a showcase in New York City in September 2018. Beyond a celebration of good food, the event is expanding awareness of the potential of plant breeding to feed our culinary desires while supporting diversity and ecology of our food crops. Produce distributors and organic food stores are also increasingly supporting new varieties, but the conversation must continue to expand to bring in more supply chain actors if we are to expand crop genetic diversity on our plates.

Synergistic movements

Several agricultural and cultural movements, beyond the organic seed sector, are changing the way we relate to our food in ways that impact crop diversity. The local food movement is inspiring regional farmers to diversify their crops to expand year round access to fresh foods with 76% growth in the number of farmers markets since 2008 and over 8,000 now across the US (Pirog et al. 2014). Healthy eating initiatives, including farm-to-school programs and local food in healthcare institutions, are expanding access and appeal of diverse, fresh foods to the broader population. Efforts to reconnect with the cultural heritage of our food crops are taking hold within diverse ethnic groups. An example is the Indigenous Seed Keepers Network, an initiative of the Native American Food Sovereignty Alliance. Efforts to preserve traditional crops and heritage varieties are also evidenced in diverse offerings at many farmers markets across the US. These movements complement the emerging farmer-centric organic seed efforts as they increase our collective awareness of the importance of diversity in our food systems and not only conserving the diversity of seed, but also preserving seed knowledge for future generations.

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Keynote

Cultivating diverse food systems in the shell of the uniform: power relations and transitions to sustainability

Philip Howard

Michigan State University

E-mail: howardp@msu.edu

Abstract

Most dominant trends in food and agricultural systems are toward specialization and uniformity, despite a long list of negative impacts that typically result. As one example, a handful of agrichemical firms now control well over 60 percent of commercial sales of both pesticides and seeds globally. Seed diversity has declined as a result of this consolidation, threatening the resilience of our food supplies in the face of climate change and emerging crop and livestock diseases.

These trends are the direct result of concentrating power in the hands of fewer and fewer people, which leads to even greater resources to reinforce these efforts. This increasing power also tends to elicit more resistance, however, as previously hidden socio-ecological impacts become more visible and limits to public acquiescence are reached.

One response has been the development of numerous counter-trends toward real diversity, such as community seed banks and open source seed breeding. Although counter-trends are currently quite small, some are growing very rapidly. These efforts are critical for maintaining a sufficient reservoir of knowledge, skills and plant and animal varieties, as more uniform food systems lose their dominance and need to be replaced.

Yet industrial food and agricultural systems currently remain dominant due to "vicious cycles" or "lock-ins" that mutually enhance their power. In 2016 the International Panel of Experts on Sustainable Food Systems noted eight lock-ins that are key to this situation: (1) path dependency, (2) export orientation, (3) expectation of cheap food, (4) compartmentalized thinking, (5) short-term thinking, (6) feed the world narratives, (7) measures of success and (8) concentration of power—the last of which reinforces all of the other lock-ins.

Efforts to cultivate diversified agricultural and food systems have to potential to overcome these lock-ins, particularly if they pay sufficient attention to the issue of power relations. This will require avoiding top-down approaches such as "scaling-up," and instead fostering decentralization, horizontal proliferation, cooperation and transparency. To develop mutually reinforcing "virtuous cycles" will require embodying our ideals as much as possible, including through everyday actions, despite the strong resistance we face. In addition, we must remain vigilant against co-optation, which some of the most successful alternatives have already experienced (e.g. organic and fair trade labels).

Transitions to more sustainable food systems are by no means assured, but participatory and transdisciplinary approaches that focus on reducing concentrations of power and cultivating diversity at micro-, meso-, and macro-levels have a strong potential to achieve these outcomes.

Scientific comitee of the congress

Véronique Chable, INRA (project coordinator), France
Riccardo Bocci, RSR, Italy
Micaela Colley, OSA, USA
Ambrogio Costanzo, ORC, UK
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