



LIVESEED

LIVESEED workshop on new concepts and strategies for organic plant breeding:

Internal report on the results of Workshop 1 for input from formal and informal breeders involved in breeding for organic farming systems for priority setting of research needs for organic plant breeding and selection methods

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1. Summary

Innovations in organic breeding are urgently needed. These innovations can include methodologies, methods and tools and cover a wide range of areas. In order to understand how these methodologies, methods and tools are interconnected and what exactly their value can be for organic breeding, and organic agriculture at large, a first concept of a systems-based breeding approach was developed. At the workshop held at the University of Kassel, Witzenhausen in Germany on February 21 2018, the concept of the systems-based breeding approach (Figure 1) was presented and discussed with all participants. The aim of the workshop was to introduce and discuss a common future vision and paradigm change for a more integrated **systems-based breeding concept**.

Organic plant breeding requires innovative breeding concepts and approaches dealing not only with technical breeding aspects, but also with broader sustainability aspects related to socio-economic, environmental, climatic and ethical factors. Following the IFOAM principles, breeders need to produce high-yielding, healthy, nutritious, resource-efficient cultivars that are climate-robust, culturally acceptable and contribute to ecosystem services, i.e. are ecologically and societally resilient. To deal with so many different aspects simultaneously is difficult.

The systems-breeding approach proposes an integration of four paradigmatic orientations that currently co-exist: community-based breeding, ecosystem-based breeding, trait-based breeding, and corporate-based breeding. Lammerts van Bueren et al. (2018), conclude that only a systems-based breeding approach can achieve all relevant sustainability targets: food security, safety and quality; food and seed sovereignty; social justice; agrobiodiversity; ecosystem services; and climate robustness. Achieving that requires specific knowledge development and integration, a multitude of suitable 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. Systems-based breeding is an overarching approach: a methodological orientation which has the potential to synergize the strengths of the ways of thinking in the current paradigmatic orientations. The LIVESEED/EUCARPIA/ECO-PB workshop on new concepts and strategies for organic plant breeding used interactive sessions to further develop various aspects of systems-based breeding concept. To operationalise the concept, two exercises were conducted at the workshop.

At the workshop all participants gave input on solutions, obstacles and examples for the systems-based breeding concept. In general, participants liked the systems-based approach, in particular to make the perspective on breeding more holistic. From the analysis it becomes clear that not only should be looked for technological solutions but also for solutions that include social, ethical and economic aspects.

Given the diversity in participants, it was also logical that there were different ideas on how to move forward. The question is who takes the lead in pushing such concept of systems-based breeding? Should it be government or a strong civil society? Community based, NGO based, and public based breeding are different approaches. There were also questions about financing breeding: how can we allow different approaches to co-exist, intermingle, and share profit?

It was also suggested to further develop the systems-based breeding concept. For example, by making it three-dimensional it becomes more dynamic. From the discussion it becomes clear that more meetings and workshops are needed to discuss the systems-based breeding approach further and to see how organic breeders can integrate the concept in their work.



2. Introduction

Innovations in organic breeding are urgently needed. These innovations can include methodologies, methods and tools and cover a wide range of areas such as:

- Socio-economic level: further developing concepts like participatory farmer based, chain based and community-based breeding
- Efficiency of different tools, criteria and methods: direct versus indirect selection (organically versus conventionally managed selection fields), GxExM interaction, indirect parameters for complex traits like NUE and WUE, efficiency of MAS, genomics, metagenomics, epigenetic effects;
- Dealing with conditions like inheritance of seed- and soil borne diseases, weed competition, trade-offs between resilience and quality in the breeding process;
- Genetic diversity concepts, resilience, local adaptation, geographical indication schemes (PDO and PGI); IP issues;
- Special goals like breeding for complex systems (mixed cropping, agroforestry, balanced plant – microbe interaction, plant communication and defence strategies).

In order to understand how these methodologies, methods and tools are interconnected and what exactly their value can be for organic breeding, and organic agriculture at large, a first concept of a systems-based breeding approach was developed¹. At the workshop held at the University of Kassel, Witzenhausen in Germany on February 21 2018, the concept of the systems-based breeding approach (Figure 1) was presented and discussed with all participants. The aim of the workshop was to introduce and discuss a common future vision and paradigm change for a more integrated **systems-based breeding concept**.

The workshop was part of the conference which addressed the topic ‘breeding for diversification’, with a focus on low input and organic farming systems, organised by **EUCARPIA** Section Organic & Low-input Agriculture, ECO-PB, DIVERSify, INSUSFAR, HealthyMinorCereals, LIVESEED, and ReMIX. The afternoon workshop session was attended by 43 participants, amongst others from commercial breeding companies, informal breeding initiatives, seed companies, NGOs, universities and independent research institutes. All of them are involved to the topic of organic breeding in one way or another.

2.1. Brief background of the concept

Organic plant breeding requires innovative breeding concepts and approaches dealing not only with technical breeding aspects, but also with broader sustainability aspects related to socio-economic, environmental, climatic and ethical factors. Following the IFOAM principles, breeders need to produce high-yielding, healthy, nutritious, resource-efficient cultivars that are climate-robust, culturally acceptable and contribute to ecosystem services, i.e. are ecologically and societally resilient. To deal with so many different aspects simultaneously is difficult. Following particular paradigmatic positions, breeders try to deal with some of these aspects but have difficulty to target all above aspects. The systems-breeding approach proposes an integration of four paradigmatic orientations that currently co-exist: community-based breeding, ecosystem-based breeding, trait-based breeding, and corporate-based breeding. Lammerts van Bueren et al. (2018), conclude that only a systems-based

¹ available at <https://doi.org/10.1007/s13593-018-0522-6>, to be cited as: Lammerts van Bueren ET, Struik PC, Van Eekeren N, Nuijten E (2018) Towards resilience through systems-based plant breeding. A review. *Agronomy for Sustainable Development* 38:42.



breeding approach can achieve all relevant sustainability targets: food security, safety and quality; food and seed sovereignty; social justice; agrobiodiversity; ecosystem services; and climate robustness. Achieving that requires specific knowledge development and integration, a multitude of suitable 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.

Systems-based breeding is an overarching approach: a methodological orientation which has the potential to synergize the strengths of the ways of thinking in the current paradigmatic orientations. Systems-based breeding should create strong interactions between all system components. While seeds are part of the common good and the basis of agrobiodiversity, a diversity in breeding approaches, based on different entrepreneurial approaches, can also be considered part of the required agrobiodiversity. To enable systems-based breeding to play a major role in creating a sustainable agriculture, a shared sense of urgency is needed to realize the required changes in breeding approaches, institutions, regulations and protocols. Based on this concept of systems-based breeding, breeders can play an active role in the development of an ecologically and societally resilient, sustainable agriculture (Figure 1).

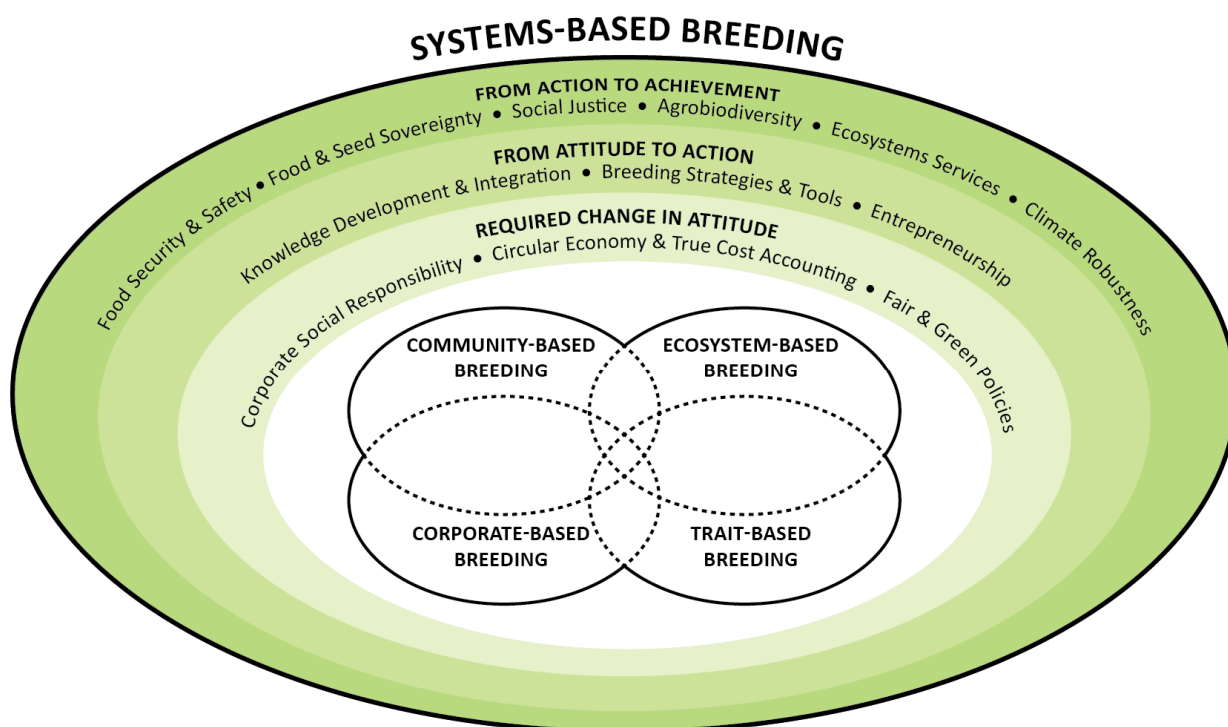


Figure 1: The systems-based breeding approach, with the aim of integrating the strengths of various breeding orientations, in that way meeting socio-economic, environmental, climatic, agronomic and ethical values (Lammerts van Bueren et al. 2018).

2.2. Workshop Program

The LIVESEED/EUCARPIA/ECO-PB workshop on new concepts and strategies for organic plant breeding used interactive sessions to further develop various aspects of systems-based breeding concept, followed by conclusions and further steps.

- 13.00-14.00** Introduction to the concept of systems-based breeding by Edith Lammerts van Bueren
- 14.00-14.20** Individual exercise to apply concept on your own breeding activities
- 14.20-15.20** Group work on how to achieve paradigm shift in breeding to reach sustainability goals (food security and safety, food and seed sovereignty, social justice, agrobiodiversity, ecosystem services, and climate robustness) (first round); how to improve knowledge development and integration, the right breeding strategies and tools, and entrepreneurship (second round); and action needed to change attitude based on corporate responsibility, circular economy and true cost accounting, and fair and green policies (third round)
- 15.20 - 15.40** *Coffee Break*
- 15.40-16.10** Presentation of group work results
- 16.10-17.00** General discussions on the systems-based breeding concepts, challenges and action needed, examples to illustrate the concept and definition of a roadmap to substantiate the concept and achieve paradigm shift in attitude

3. Operationalisation of the concept

To operationalise the concept, two exercises were conducted at the workshop. The first one was an individual exercise for participants to see their own breeding performance from the systems-based breeding perspective. Participants were asked to assess their position based on a spider diagram with 12 key-elements of the systems-based breeding approach (Figure 2). The definitions of the 12 key-elements are described in Table 1. Participants were then asked to discuss in small groups their individual assessments. Which aspects are they dealing with in their current work, and which aspects require more attention? The participants could take the assessments home and compare over time. The second exercise was a joint exercise to define solutions, obstacles and examples for systems-based plant breeding. All participants were asked to write solutions, obstacles and examples on post-it's and discuss these post-it's in groups. Group size was 6 to 8 people and in total there were six groups. After the group discussions each group presented their results in a plenary session (Figure 3). The workshop was closed after a plenary discussion.

Figure 2. Spider diagram as assessment tool for the 12 key-elements of the systems-based breeding approach.

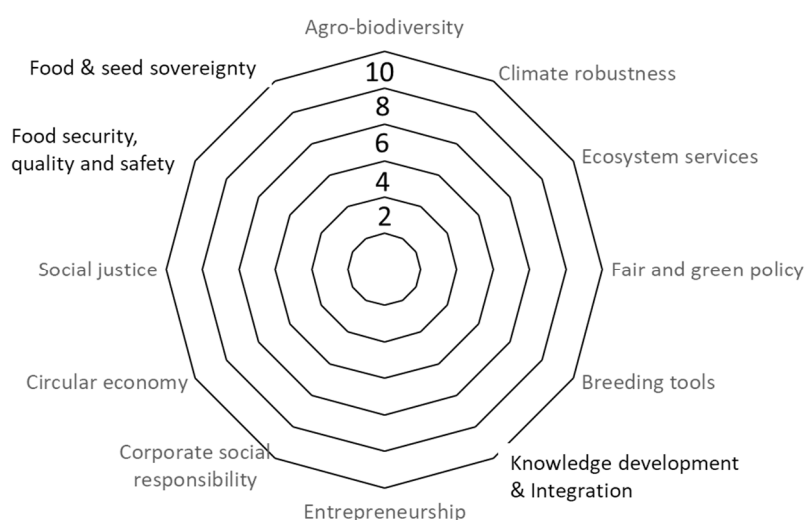




Figure 3: Photos of the workshop, with presentation of the introduction, people working on exercise two group discussions, several flip charts with results and presentation of the results.

Table 1: Key elements and aims of the systems-based breeding orientation (Lammerts van Bueren et al. 2018).

	Key elements	Aims
Required change in attitude	Corporate social responsibility	Including ethical and social responsibilities beyond, legal and economic responsibilities
	Circular economy & True cost accounting	Rearranging linear relationships such that value chains become value networks in which various actors work together
	Fair & green policy	Creating a frame for optimal integration of all components of systems-based breeding
From attitude to action	Knowledge development and integration	Supporting continuous development of specialised, generalised and integrated knowledge at various levels (socio-economic, agro-ecological, etc.)
	Breeding strategies and tools	Designing a range of different appropriate technical breeding approaches
	Entrepreneurship	Developing sound entrepreneurial models suitable for various small and large value chains
From action to achievement	Food security, safety & quality	Enhancing breeding of food that is healthy, nutritious and safe, with high and stable yield, and good shelf-life that does not require chemicals during production and storage
	Food & seed sovereignty	Allowing a pluriformity of breeding models to co-exist and for communities and markets to choose breeding models that fit best, implicitly serving cultural diversity and seeds as common good
	Social justice	Fair and just assigned rights and duties in relation to breeding activities and products, such as breeders' privilege and farmers' rights
	Agrobiodiversity	Enhancing agro-biodiversity in farming systems; within and among crop species; improve diversity in major and small crops
	Ecosystem services	Improving breeding strategies, breeding products and crop traits that support ecosystem services
	Climate robustness	Creating climate robust and flexible breeding strategies and products that provide yield and quality stability under variable conditions

4. Workshop results

The results of the first exercise were not collected as it was considered useful for participants themselves to take the results home for further reflection. It was an exercise to get the participants committed to the topic. Feedback from participants varied such as: difficult, challenging and useful.

The results of the second exercise were collected for further analysis. In total 85 solutions, 68 obstacles, and 39 examples were mentioned. Table 2 shows the solutions, obstacles and examples organised by the four categories defined in Figure 4. For the solutions, most examples fall in the category Science and Technology (33%), followed by Market and Industry (27%). Most obstacles were categorised under Market and Industry (37%), followed by Policy and Governance (32%). Clearly most examples fall under the category Market and Industry (54%). The following tendencies can be observed:

- Although the percentage of obstacles for Policy and Governance was quite high, the number of examples for this category is much lower.



- The category Market and Industry had the highest percentage of obstacles, but also the highest percentage of examples, and a high percentage of solutions.
- Science and Technology had the highest percentage of solutions and a quite high percentage of examples
- Overall, the category Societal and Cultural Norms and Values had the lowest percentages, and scored particularly low for the examples

Table 2: Solutions, obstacles and examples mentioned at the workshop in Witzenhausen 2018, organised in four categories/environments as described in Figure 4.

Category		Solutions (in %)	Obstacles (in %)	Examples (in %)
	N =	85	68	39
Market and Industry	69	27%	37%	54%
Policy and Governance	43	18%	32%	15%
Science and Technology	51	33%	18%	28%
Societal and Cultural Norms and Values	29	22%	13%	3%

The 85 solutions, 68 obstacles, and 39 examples were grouped into 68 sub-categories to understand which topics were mentioned most often. The 16 most-mentioned sub-categories are shown in [Table 3](#). Of the *solutions*, the sub-categories most often mentioned were ‘collaboration in breeding’, ‘market reorganisation’ and ‘knowledge sharing’. Together they describe an idea for organising breeding in a different way. For the *obstacles*, the most often mentioned sub-category was ‘law and regulations’, followed by ‘short term profit’ and ‘long term funding’. These issues are also commonly mentioned as key obstacles for organic breeding. As *examples* for new approaches in breeding were most often mentioned ‘breeding for diversity’, ‘collaboration in breeding’ and ‘new initiatives’. Together they describe the wish to organise the market in a different way.

Table 3: The sub-categories with most mentioned solutions, obstacles and examples at the workshop in Witzenhausen 2018

Sub-category	Solutions	Obstacles	Examples	Total
N =	47	34	28	109
collaboration in breeding	8	1	5	14
breeding for diversity	4	0	6	10
law and regulations	0	7	3	10
market reorganisation	6	2	2	10
knowledge sharing	6	3	0	9
role of farmers in breeding	3	2	3	8
integrated system approaches	3	1	2	6
new initiatives	2	0	4	6
breeding tools	3	1	1	5
long term funding	1	4	0	5
policy and politics	2	2	1	5
short term profit	0	5	0	5
knowledge development	2	2	0	4
networking	4	0	0	4
ownership / IPR	1	2	1	4
public funding	2	2	0	4



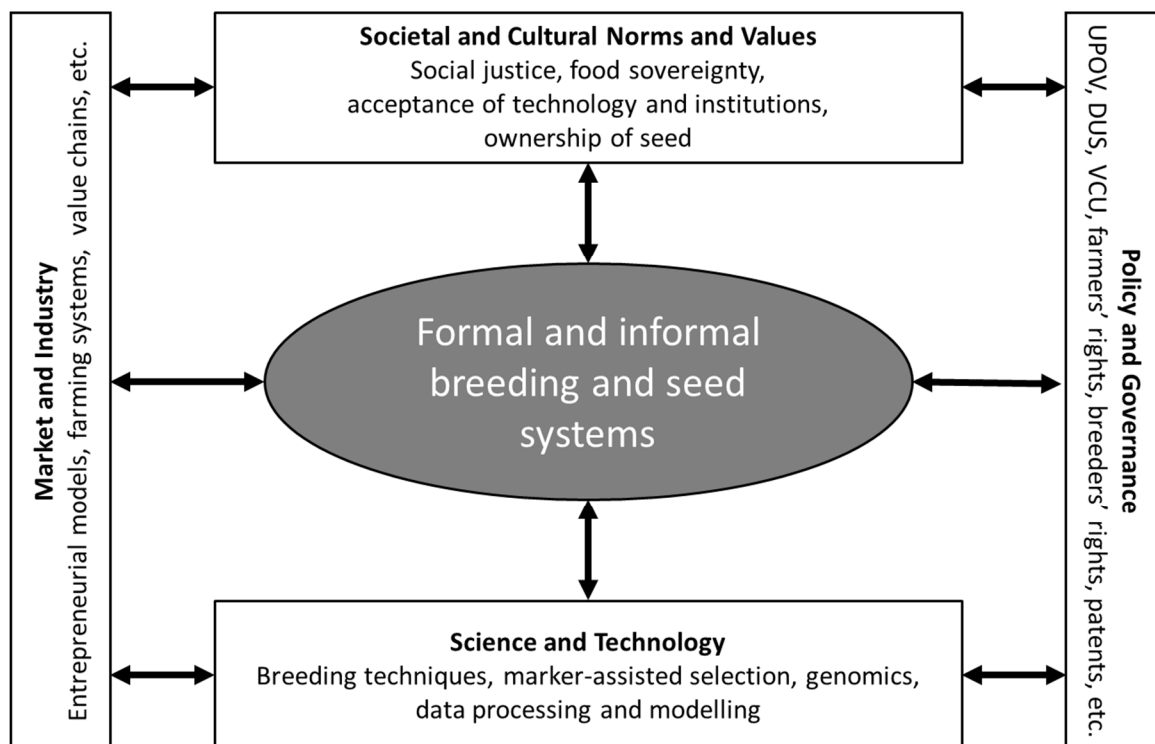


Figure 4. Roles and positioning of breeding and seed systems within their economic, scientific, institutional and cultural environment (Lammerts van Bueren et al. 2018).

Table 4 shows a range of issues related to each of the twelve key elements that need to be addressed or require more attention. An overarching theme is that more collaboration in breeding is needed, at all levels. Many issues were mentioned for Circular economy & True cost accounting, Fair & Green policy and Knowledge development and integration. For climate robustness only one aspect was mentioned: the trade-off between traits and services, meaning to look for balance between improved robustness and other services needed.

Table 4 also shows that the market and industry environment in Figure 4 (abbreviated to market in Table 4) is not only related to the key element 'entrepreneurship' only, but that there is also relationships between the other key elements and the market. Likewise, the key element 'knowledge development and integration' is not only related to the science and technology environment in Figure 4 (abbreviated as 'science' in Table 4). The same goes for the key element 'fair & green policy' as it is not only connected to the policy and governance environment and the key element 'corporate social responsibility' and 'circular economy & true cost accounting' that are not only related to the cultural environment.

Table 4: Issues related to the various key elements, based on analysis of the second exercise at the workshop in Witzenhausen, 2018.

Category in Figure 4	Related issues	Required change in attitude			From attitude to action			From action to achievement					
		Corporate social responsibility	Circular economy & True cost accounting	Fair & green policy	Knowledge development and integration	Breeding strategies and tools	Entrepreneurship	Food security, safety & quality	Food & seed sovereignty	Social justice	Agrobiodiversity	Ecosystem services	Climate robustness
market	feedback from end users				1		1						
market	market reorganisation / involvement of value chain/consumer		1						1				
market	collaborative business models						1						
market	contact with all value chain actors, market demands						1						
market	creating participatory network								1				
market	CSA movements / social enterprises /decentralised seed enterprises						1						
market	develop networks between consumer and producers			1									
market	development of labels						1						
market	different target environments, target users and broad community								1				
market	diversity in needs and interests								1				
market	foster regional and local value chains (e.g. reduce high consumption of global products)										1		
market	long term experience (Pioneer role)				1								
market	new business models						1						
market	new financing models						1						
market	new initiatives						1						
market	shorter process ways		1										
policy	public funding for breeding for 'minor crops'				1			1					
policy	role of public breeding / pre-breeding		1		1								
policy	access to diversity								1				
policy	address temporal and quantitative limitation to the marketing (EU 2015/150)			1									
policy	adjustment of seed laws									1			
policy	convention on biodiversity; Nagoya protocol										1		
policy	corporate social responsibility											1	



policy	facilitate networking			1															
policy	fair breeding			1															
policy	funding (Royalties / Public); Return of investment; ownership / IPR									1									
policy	funding to maintain genetic resources																	1	
policy	improve law and regulations; suitable rules for SME/ individuals; limited administrative burden for individuals: registration process too complex			1															
policy	legal restrictions									1									
policy	long term (public) funding			1															
policy	political and institutional support; policies to support long term thinking in breeding initiatives; national plan of action			1															
policy	Seed marketing laws allowing space for following the traditions																	1	
policy	support diversity in breeding initiatives			1															
science	breeding for diversity /agrobiodiversity / agroforestry					1	1											1	1
science	breeding tools					1				1									1
science	integrated system approaches; knowledge at all levels (scientific, practical, social, economic)		1			1	1												
science	trade-off between traits and services									1									1 1
science	adapting varieties to local conditions										1								
science	knowledge sharing / knowledge transfer / training and education					1	1												
science	connect marginal and neglected species with valorization PPB programs																		1
science	education and training on breeding			1															
science	focus on ecological systems (e.g. knowledge development)																		1
science	good co-designing dynamics between scientists & customers, farmers, advisory services					1													
science	independent facilitator					1													
science	knowledge on certain crop species									1									
science	spatial limitations, G x E interactions																		1
science	transparency					1													
norms	collaboration in breeding		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
norms	role of farmers in breeding	1	1		1	1													1
norms	awareness raising / consumer life style		1	1						1									
norms	benefit sharing	1	1																1
norms	focus not only on short term profit	1	1	1															



norms	address interest of farmers and breeders; a.o. finding the right price for seeds together with producers	1	1																
norms	agreement on goals / concrete goals			1			1												
norms	credibility and reliability, dedication	1	1																
norms	include socio-economic aspects: a.o. address aspects that give no revenue	1	1																
norms	networking		1				1												
norms	broaden price determining factors		1																
norms	common identity / language					1													
norms	female empowerment	1																	
norms	finding partners who feel responsible; good relationships		1																
norms	have open attitude, no prejudice		1																
norms	keeping competition in balance	1																	
norms	two-way interaction between breeding and seed multiplication											1							
norms	willingness to work together; discuss motivations	1																	
other	human resources								1										
other	public private partnerships																		1
other	renewable resources																		1
other	resources for testing under different pedo-climatic conditions							1											

5. Discussion and next steps

At the workshop all participants gave input on solutions, obstacles and examples for the systems-based breeding concept. In general, participants liked the systems-based approach, in particular to make the perspective on breeding more holistic, and that it avoids polarisation between views and rather shows how to look for synergies.

From the analysis it becomes clear that not only should be looked for technological solutions but also for solutions that include social, ethical and economic aspects. However, the analysis also shows that there is a bias in the thinking: most obstacles and examples were connected to the category/environment Market and Industry, followed by the category Science and Technology with the highest percentage of solutions and also a high percentage of examples. These results underline a bias connected to the breeding orientations 'corporate-based breeding' and 'trait-based breeding'. In the plenary discussion some mentioned that it is important to have the social element integrated in breeding: amongst others to keep genetic resources available for future generations. Another reason is that breeding is not only a technical exercise but also an organizational exercise, a network of relations. Others commented that already at the time of the CGIAR the question was how to get the social element more integrated into breeding, as the social and physical environment are determinant. And there was the question how to pay more attention to gender? Some mentioned that the entrepreneurial context is important, one needs to earn money in order to invest in breeding.



Others commented that breeding as creative process should be disconnected from the business-oriented seed production and selling.

As climate change becomes urgent it may also provide a chance for the needed integration. However, only a few issues related to climate robustness were mentioned to be further elaborated. In terms of achievements as defined in Table 1, food & seed sovereignty, social justice, agrobiodiversity and ecosystem services received more attention from the participants. One could also argue that climate robustness will also be addressed together with agrobiodiversity and ecosystem services.

Given the diversity in participants, it was also logical that there were different ideas on how to move forward. The question is who takes the lead in pushing such concept of systems-based breeding. Should it be government or a strong civil society? Community based, NGO based, and public based breeding are different approaches. There were also questions about financing breeding: how can we allow different approaches to co-exist, intermingle, and share profit?

It was also suggested to further develop the systems-based breeding concept. For example, by making it three-dimensional it becomes more dynamic. From the discussion it becomes clear that more meetings and workshops are needed to discuss the systems-based breeding approach further and to see how organic breeders can integrate the concept in their work. In several follow up meetings this was discussed further. We need to realize that it is important to consider the development of the systems-based breeding approach as an ongoing process.

At a LIVESEED workshop connected to the DIVERSIFOOD final congress (12 December 2018), participants emphasized that the financing of plant breeding needs to be changed as well. It is not possible to organize breeding in a different way, if the financing part remains unchanged. The LIVESEED workshop at BioFach 21 February 2019 emphasized that, in addition, changes in relationships within the value chain are needed as well. At the second annual meeting of LIVESEED (15 May 2019) participants of a brief open session mentioned that it is important to realize and understand how exactly breeding has changed over the last 50 years. It was concluded that we need to work on various levels at the same time: financing, increasing social awareness, and developing appropriate breeding methods. An important lesson was that the sharing of knowledge, tools and crop material has changed a lot over this period. What exactly fair sharing is, needs to be further discussed. Another lesson was that reflection is important to realize changes in attitude, the first 'building block' of the systems-based breeding approach. Reflection is both an individual and a group process. In that respect it is noteworthy that this LIVESEED workshop also inspired two breeding companies in Switzerland (Sativa and GZPK) to jointly organize a follow-up, in-company workshop to reflect on and discuss this concept of systems based breeding among their co-workers and use it as a policy instrument to lead future development of their companies in a more holistic way. This workshop was organized on 16 April 2019 and hosted by FiBL-CH and led by Edith Lammerts van Bueren.

6. References

Lammerts van Bueren, E. T., Struik, P. C., van Eekeren, N., & Nuijten, E. (2018). Towards resilience through systems-based plant breeding. A review. *Agronomy for Sustainable Development*, 38(5), [42]. <https://doi.org/10.1007/s13593-018-0522-6>

