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SYSTEMS-BASED BREEDING APPROACH: HOW TO IMPLEMENT IT?

Edwin Nuijten¹, Monika Messmer², Pedro Mendes Moreira³, Adrian Rodriguez Burruezo⁴, Edith Lammerts van Bueren⁵

¹De Beersche Hoeve, Oostelbeers, Netherlands, ²FIBL, Frick, Switzerland, ³IPC, Combría, Portugal, ⁴UPV, Valencia,

Spain, ⁵WUR, Wageningen, Netherlands

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Abstract: Organic breeders need to meet many demands in developing cultivars, e.g. with high yield, good quality, resource-efficiency, climate-robustness, and culturally and ethically acceptable and contributing to ecosystem services. Given the current and future climatic, agronomic, economic and societal environment working towards ecological and societal resilience can only be achieved by concerted action. The concept of systems-based breeding tries to integrate the strengths of different breeding orientations and provides a perspective where breeders can be initiators of developments towards an ecologically and societally resilient crop production. In this paper we present the first steps for operationalising this concept.

Introduction: Breeders need to develop – in a societally acceptable manner – high-yielding, good quality, resource-efficient cultivars that are climate-robust, culturally acceptable and contributing to ecosystem services. Lammerts van Bueren et al (2018) analysed several challenges towards ecological and societal resilience given the current and future climatic, agronomic, economic and societal environment, which can only be properly addressed by concerted action. Four paradigmatic breeding orientations were identified: community-based, ecosystem-based, trait-based, and corporate-based, each with different mindset, values and economic models. Each approach has significant impact and value, such that none alone will achieve all relevant sustainability targets: 1) food security and safety, 2) food and seed sovereignty, 3) social justice, 4) agrobiodiversity, 5) ecosystem services, and 6) climate robustness. Achieving these targets requires i) knowledge development and integration, multiple breeding strategies and entrepreneurs, but also a change in attitude based on ii) corporate responsibility, circular economy and true cost accounting, and fair and green policies. Together with the six sustainability targets, these are key-elements for an innovative game-changing 'systems-based breeding approach' (Table 1). This overarching concept of systems-based breeding (Figure 1) tries to integrate the strengths of different orientations and provides a perspective where breeders can be initiators of developments towards an ecologically and societally resilient crop production. In this paper we present the first steps for operationalising this concept.

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

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

Material and methods: The concept of the systems-based breeding approach has been discussed with organic breeding practitioners and with actors of the value chain in several workshops in 2018 and 2019 in the frame of Horizon 2020 project LIVESEED and beyond:

2018 February: Workshop at Seed Growers Conference in Corvallis, USA

2018 February: Witzenhausen workshop in Germany

- Presentation of holistic perspective on organic plant breeding and sharing of ideas on further developments (LIVESEED Deliverable 3.10)

2018 December: workshop linked to Diversifood Congress in France

- Further elaboration of the system-based breeding concept and next steps

2019 February: Biofach workshop in Germany

- Working with the holistic perspective on organic plant breeding: how to implement it? (LIVESEED Milestone 3.5)

2019 April: FIBL workshop with two Swiss biodynamic breeding companies

- Reflection on the key elements of the system based breeding approach from a company perspective

The outcomes of these meetings have been analysed in various ways, with statistical analysis and by distilling crucial steps for practitioners to work with the concept.

Results: To be able to operationalise this methodological orientation and to internalise it in the daily practices of organising their breeding program, practitioners will need to reflect on how they are currently managing their breeding, and how they could adjust their breeding practices in the future, including the socio-cultural and ethical aspects. The workshop in Witzenhausen 2018 showed that a first step is a self-evaluation of the own breeding according to the 12 key-elements. This can be done with elaborated descriptions and concrete examples of each of the key-elements (Table 1). A second step is group reflection as the discussions will then deepen the understanding and allow better internalisation of the concepts. Participants defined in group work Solutions, Obstacles and Examples for systems-based plant breeding. The most-mentioned Obstacles were 'law and regulations', 'short term profit' and 'long term funding', while Solutions were seen in 'collaboration in breeding', 'market reorganisation' and 'knowledge sharing'. Together they describe a common idea for organising breeding in a different way, with more collaboration of the value chain.

This group process creates awareness on the importance for openness for other values, diversity and thought styles. However, to achieve changes in attitudes continuous dialog at different levels are necessary. In April 2019 two Swiss biodynamic breeding companies were guided to assess their present status in respect of the key elements and to define common target where they want to improve the next 5 years. This process can gain value when it is done repeatedly/regularly as the process can be considered similar to peeling an onion to come to the essence of the organisation in its ecological and societal context. With the first cycle of reflection, the obvious will be discussed. The next

cycle of reflection, the less for granted issues will emerge and be challenged. If the targets are clear, they can be used as benchmark and implemented in the strategy of the organisation.

Change of attitude is not the sole responsibility of breeding practitioners. Government, value chain actors and citizens also have a role to play. A general lesson from the workshop at Biofach 2019 was that communication is very important. With value chain actors, we need to talk about the advantages of organic plant breeding at various levels: at the practical level, but perhaps more importantly at the emotional and spiritual level. In order for citizens to take their responsibility, it is necessary to set up virtual and physical platforms where citizens can meet. As breeding has become distant from daily life and difficult to understand for many citizens, it is important to create more awareness and distribute information about today's breeding practices and let citizens experience the results of breeding, through taste tests and field visits for example.

Another important element to operationalise the systems-based breeding approach is a larger diversity in funding approaches. Currently, the dominant approach for funding breeding (the mainstream model) is through the seed sales. However, this does not work for breeding approaches, such as community based and ecosystem based breeding. Here other funding schemes are needed to account for the benefit for society. Seed sales should cover the costs for seed production, whereas breeding can also be considered part of the cultural heritage and the commons, and thus should receive financial support by the government or the value chain. In order to foster these processes of change, regular dialog with the value chain and public authorities should be put in place. Citizens can be reached with appropriate labelling and can be involved in funding as well.

Discussion: The workshop analyses showed that not only should be looked for technological solutions but also for solutions that include social, ethical and economic aspects. Collaboration and value chain partnerships seem to be key elements for change towards ecologically and socially resilient food systems. Elaborating the methodological approach will help integrate the concept of systems-based breeding into daily practices. Research on multi-actor approaches showed that a continuous critical evaluation through reflection of the whole process is needed (Rossi et al. 2019). This can help to manage the process fruitfully and coherently in relation to the commitment to contribute to generate change in food systems, that is to play a transformative role.

It should not only be a government or a strong civil society pushing for a diversity of approaches, but gradual change should also come from within breeding companies. An important issue to be further elaborated is the financing of breeding: how can we enable different approaches to co-exist, is it possible to combine or integrate financing approaches and related economic models, and how can we ensure breeding for society?

The higher the diversity in breeding approaches and the more initiatives, the more agrobiodiversity can be maintained and bred for, which is also important to make agriculture more climate robust. In addition, diversity in breeding approaches and initiatives will foster the development and maintenance of knowledge, and it will help keep an open mind on what seeds are: that they are not only commodities, but that they are also culture and part of common heritage.

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Image:

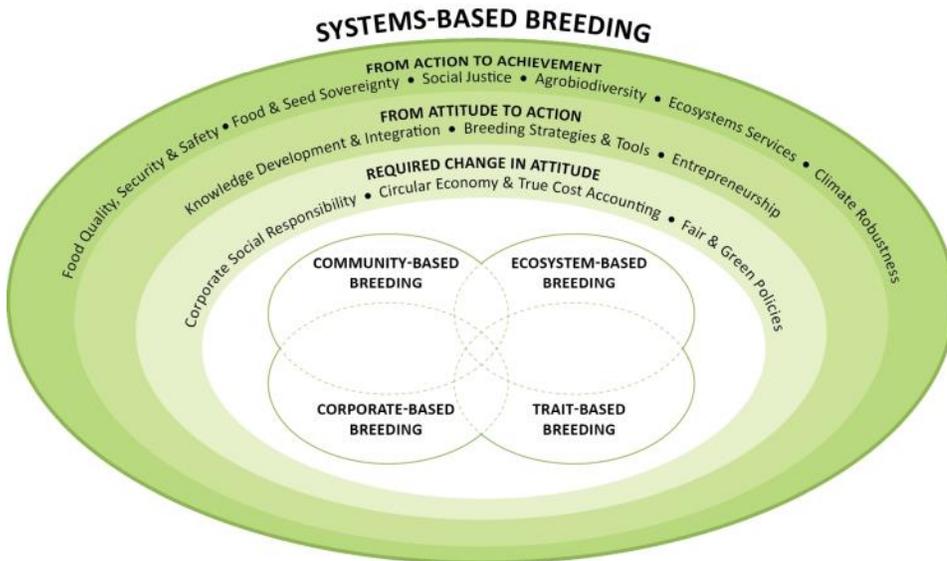


Image 2:

	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

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Keywords: agrobiodiversity, breeding strategies, ecological resilience, new approaches, seed systems, societal resilience