Policy Brief

Systems-based Plant Breeding

Main findings

- In order to reach the goals set out for organic farming in the EU, the most important organic input - organic seed - must be made widely available.
- To create new varieties for organic farming in a sustainable way, the organic plant breeding sector must be further developed.
- New breeding models, such as the systems-based breeding, rethink the relationships around organic plant breeding and embed the sector into the wider sustainability context. In this new concept "system" is defined as the space that encompasses the civil society, policy, nature, agriculture and value chains as interrelated and mutually dependent components.
- In order to put the concept into practice, twelve key elements were identified, along with their key goals, the most pressing issues to tackle, and their relevance for policy.

Key policy recommendations

- EU agricultural policy should be improved to strengthen organic plant breeding (OPB). Specifically, the CAP remains the main policy instrument that represents an opportunity to make OPB a priority through greening measures and eco-schemes.
- 100% organic products deriving from organically produced seed and breeding materials could be integrated into the criteria for sustainable food public procurements.
- OPB presents a valuable link to sustainable agriculture, ecosystem services, climate change mitigation and biodiversity in corporate sustainability and social responsibility strategies and its inclusion should be promoted.
- Measures are needed to support participatory organic plant breeding which boosts social sustainability in rural areas and the co-development on knowledge.

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Farm to Fork

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Context

A sustainable food system has reduced environmental impact, mitigates the effects of less predictable weather events, pests and diseases, while increasing food security and quality.

Organic farming contributes significantly to achieving such a resilient food system, for which it has been recognised by several key global and EU policies. Central to the **European Green Deal**, the **Farm to Fork Strategy** set out a target to increase organic farmland to 25% of all EU farmland by 2030.

Organic farming makes the use of pesticides and chemical fertilizers obsolete, therefore greatly contributes to targets on polluting less the soil, water and air (Sanders & Hess, 2019), such as set in the **EU's Zero Pollution** ambition and the **Circular Economy Action Plan.**

Organic practices increase agro-biodiversity, provide a heterogenity of crops and landscape, reverse the loss of pollinators, and help restore the ecosystem functions of a landscape. With these the sector heavily contributes to the **EU Biodiversity Strategy** and to **United Nations Sustainable Development Goals.**

Moreover, organic farming is key to implement the **FOOD 2030 Policy Framework**, providing high quality nutrition for healthy diets and empowering communities to innovate sustainable food systems.

In order to reach the goals set out for organic farming at the EU-level, the most important organic input - **organic seed** - must be made widely available. The EU Organic Regulations have set out a deadline to **use only organic seed in organic farming as per 2036**. However, of inputs, **seed is one of the most R&D intensive industries and currently, organically produced seeds are lacking on the market**. Breeding new varieties is time intensive, also for organic farming. In order to develop diverse organic agrosystems, a large diversity of organic varieties is needed in Europe to suit local farming conditions. Breeders, furthermore, are challenged to produce cultivars for six international sustainability targets: food security, safety and quality; food and seed sovereignty; social justice; agrobiodiversity; ecosystem services; and climate robustness.

Currently, there is a lack of attention on the very important role and the needs of **organic plant breeding (OPB)**. To create new varieties for organic farming, the organic breeding sector must be further developed, taking into account socio-economic, environmental, climatic and ethical factors. New breeding models, such as the **systems-based breeding**, rethink the relationships around organic plant breeding and embed the sector into the wider sustainability and food system context.

Key results

Four major orientations of plant breeding have been identified, as a result of different combinations of subjectivism and objectivism and of holism and reductionism. These four combinations, termed "paradigmatic positions," have different styles of thought.

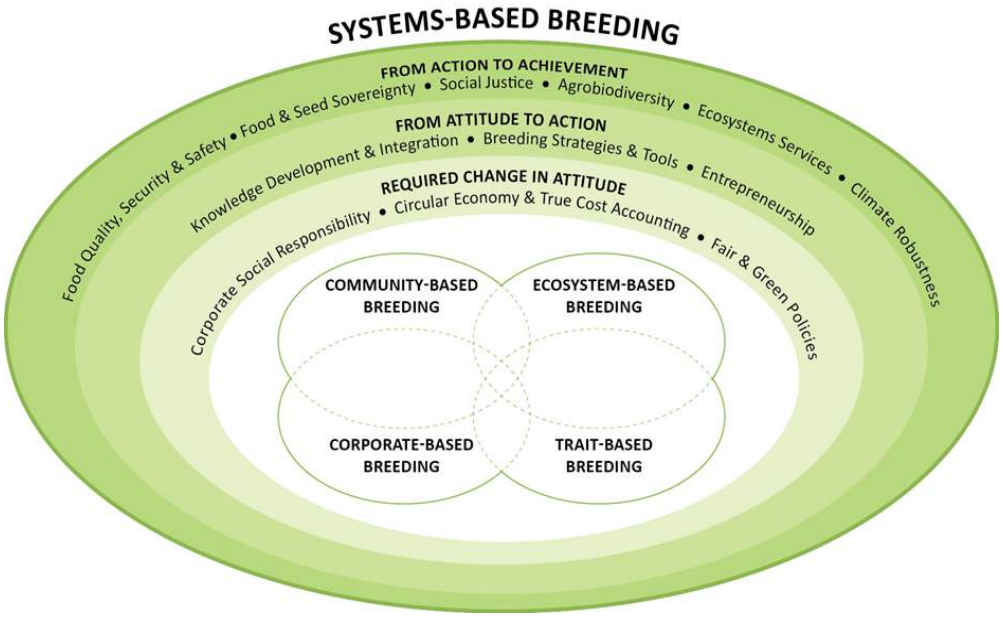
Community-based breeding restores or renews alliances as part of local, innovative food systems supporting food sovereignty and cultural diversity. Ecosystem-based breeding supports developing varieties adapted to specific pedo-climatic growing conditions at regional level. Corporate-based breeding aims to meet particular wishes and needs of the market, whereas trait-based breeding departs from the notion what kind of crops society needs to boost future crop production, and aims to dig deeper into the genetics behind the underlying traits.

In industrialized countries, breeding has gradually grown towards more corporate & trait-based breeding, with highly specialized, internationally opreating multinational companies. Private companies concentrate more and more on a limited assortment of cash crops in an economically highly competitive market.

To keep up with the growing demands of the EU organic market, and to contribute to the realization of a productive, truly sustainable agriculture a balance is needed between the efforts in the four breeding orientations.

An overarching, integrative, fifth style of thought was developed by Lammerts van Bueren et al. (2018), focusing on building synergy and balance between all four breeding orientations.

In this new concept of systems-based breeding, "system" is defined as the space that encompasses the civil society (with its diversity of cultural norms and values), policy (with various governance institutions), nature (including the diversity of pedo-climatic conditions and habitats), agriculture (including the diversity of agro-ecosystems and farming systems), and value chains and markets as interrelated and mutually dependent components of the entire system.



In order to put the concept into practice, i.e. to arrive to a sustainable breeding system, three key-processes must be enabled: a change in attitude; a process from attitude to action, and a process from action to achievement. Table 1 below explains the key elements and aims of the systems-based breeding orientation. Several workshops with the value chain actors, breeders, scientists and society, organised in the framework of the Horizon 2020 funded LIVESEED project helped verify the concept and identify the most pressing areas of policymaking that would help implement the key elements.

	Key elements	Key determinants	Link to policies	Most urgent issues to tackle
Required change in attitude	**Corporate social responsibility (CSR)** Including ethical and social responsibilities beyond, legal and economic responsibilities	1.Balancing Purpose, People, Planet, Profit (4 P's) in daily practices, with a focus on improving human capital (and transparency). 2.Respecting diversity of societal norms and values, while interacting with society.	EU strategy on CSR and Responsible Business conduct, EU Action Plan for Organic Farming	-Educating citizens and companies on the benefits of organic plant breeding (OPB). -Integrating OPB in Corporate Social Responsibility and Corporate Sustainability Strategies. -Linking OPB in CSR to ecosystem services, climate change mitigation and biodiversity.
	Circular economy & True cost accounting Rearranging linear relationships such that value chains become collaborative value networks	1. Renewing relationships (co-responsibility) in the value chain and changing value chains into food systems (food networks) for common goals on sustainability, and long-term stability through the entire food system. 2. Applying transparent, true cost accounting (true pricing) (accounting for ecological and societal costs (health and justice) made and benefits realised during production, storage, processing, transport, marketing).	EU Circular Economy Action Plan 2020	-Assessing the true costs and benefits of organic food production systems that are based on OPB with implications for everyone. -Analysing the role OPB plays in circular economy.
	Fair & green policy Creating a frame for optimal integration of all components of systems-based breeding	1. Contributing to (public or governmental) designing of fair & green policies stimulating a diversity of breeding initiatives and approaches. 2. Developing a range of appropriate protocols for DUS, VCU testing, heterogeneous material, etc.	Green Deal, Farm to Fork Strategy, Common Agricultural Policy (CAP)	-Support networking within breeding initiatives and the value chain. -Long term planning and public funding for breeding: organic breeding activities are currently financed publically and through foundations. These short term funding opportunities do not cover the entire breeding process (takes in about 10-15 years) for a new cultivar. -Provide support for small breeding SMEs who lack knowledge on the cultivar registration processes, have high administrative burden during registration processes which are too complex. -Boost the further development of appropriate testing protocols for organic varieties and organic heterogenous materials.

	Key elements	Key determinants	Link to policies	Most urgent issues to tackle:
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.)	1. Sharing and nurturing knowledge development on all aspects of the systems-based breeding concept; 2. Developing good co-designing dynamics between actors in the food system (scientists, consumers, farmers, breeders and advisors).	Green Deal, Farm to Fork Strategy, EU Action Plan for Organic Farming	-Funding breeding for minor crops to support knoweldge exchange. -Educate small SMEs on which breeding technologies can be applied that are compatible with organic breeding. -Support participation of the entire food system actors in organic breeding.
	Breeding strategies and tools: Designing a range of appropriate technical breeding approaches	1. Developing breeding strategies to involve food system actors 2. Sharing knowledge on trade-offs between aspects such as yield, quality, taste, storability and ecosystem services of crops.	Green Deal, Farm to Fork Strategy, EU Action Plan for Organic Farming	-Supporting the development of appropriate technical breeding approaches to suit the needs of locally adapted varieties across the EU and support knowledge development on trade-offs between plant traits.
	Entrepreneurship: Developing sound entrepreneurial models suitable for diverse value chains	1. Initiating collaborative, decentralized business models, new forms of financing, social enterprises. 2. Sharing corporate profit or co-ownerships among employees, breeding/food communities, etc.	Green Deal, Farm to Fork Strategy, EU Action Plan for Organic Farming	-Educate small breeding SMEs on entrepreneurship, development of value chain for new cultivars and on market entry. -Support the development of new business and financing models for OPB.
From action to achieve-ment	**Food security, safety & quality:** Enhancing breeding of food that is healthy, nutritious and safe, with high and stable yield, and good shelf-life without chemicals during production and storage	1. Developing cultivars or populations that combine good nutritional quality with yield (stability) and good shelf life. 2. Broadening the crop range (amongst others by including minor crops) in order to diversify food and hence nutrition.	Green Deal, Farm to Fork Strategy, FOOD 2030 Policy Framework	-Developing a holistic seed health strategy. -Develop breeding for diversity and high nutritional quality -Investments for breeding of minor crops.
	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	1. Creating a framework to allow communities to choose and work with their preferred diversity of food and seed. 2. Developing breeding models to allow seed sovereignty in breeding activities (e.g. no CMS and patents), e.g. allowing farm saved seed production, partnering with farmers who want to do on-farm selection.	Green Deal, Farm to Fork Strategy, Common Agricultural Policy (CAP)	-Lack of support to allow and stimulate diversity in breeding initiatives, and legal restrictions to diversity due to patents or CBD Nagoya Protocol.
	Social justice (in breeding): Fair and just assigned rights and duties in relation to breeding activities and products	1. Acknowledging breeder's rights and farmer's rights. 2. Agreeing on fair prices for contract seed producing farmers.	Common Agricultural Policy (CAP), Nagoya Protocol CBD	-Return of investment; ownership / Intellectual Property Rights. -Traditional varieties often do not meet the DUS standards for registration and therefore seed marketing laws should allow space for following traditions. -The use of amateur and conservation varieties are problematic under the current marketing regulations (EU 2015/150).
	Agrobiodiversity: Enhancing agro-biodiversity in farming systems; within and among crop species; improve diversity in major and small crops	1. Enhancing genetic diversity between and within crop species, including both minor and major crops, at farm level, and also at farming systems level. 2. Developing co-evolutionary breeding for mono-cropping, mixed cropping and agro-forestry systems, benefiting from plant-soil interactions next to plant-plant interactions.	EU biodiversity strategy, Farm to Fork Strategy, Nagoya Protocol CBD	-Long term funding to maintain genetic resources because gene banks can't maintain all material, therefore more and more diversity is stored by private enterprises. -Funding the breeding of minor crops to maintain agro-biodiversity in farming systems because commercial enterprises are focusing only on economically important crops.
	Ecosystem services: Improving breeding strategies, breeding products and crop traits that support ecosystem services	1. Developing breeding strategies and models for utilising and contributing to ecosystems services, with a focus on below-ground traits such as: enhanced rooting systems to contribute to soil organic matter, resource use efficiency, and benefiting from interaction with soil-micro-organisms. 2. Understanding trade-offs between traits such as yield and ecological valuable traits such as flower morphology (to maintain access for pollinators).	EU biodiversity strategy, EU strategy on CSR and Responsible business Conduct	-Breeding crops with traits that support ecosystem services Linking OPB in CSR to ecosystem services, climate change mitigation and biodiversity. -Assessing the impact of breeding on the ecosystem (e.g. on pollination).
	Climate robustness: Creating climate robust and flexible breeding strategies and products that provide yield and quality stability under variable conditions	1. Utilising plant phenotypic plasticity to develop yield and quality stability under unpredictable weather patterns. 2. Identifying and developing material with the ability to adapt to local contexts.	EU Biodiversity Strategy	-Breeding crops for climate robustness. -Linking OPB in CSR to ecosystem services, climate change mitigation and biodiversity. -Optimize strategies to benefit from plant-soil and plant-plant interactions.

Policy recommendations

Results from LIVESEED show that the implementation of a systems-based breeding can contribute to the objectives of EU-policies on agriculture, biodiversity and ecosystem services, sustainable development, corporate social responsibility and beyond, since it takes into account the long-term social and ecological benefits beyond the direct short-term interests of the value chain.

Most urgently, the EU agricultural policy should thus be improved to strengthen organic plant breeding (OPB). Specifically, the CAP remains the main policy instrument that represents an opportunity to make OPB a priority through greening measures and eco-schemes. **National CAP action plans should support OPB** directly by:

• Setting policy targets for organic farming and organic plant breeding, and providing financial support for farmers who are breeding under organic conditions, potentially under CAP Pillar I direct payments, and reward breeders for contributing to ecosystem services and agro-biodiversity.

• Incorporate OPB as a key agricultural practice under conversion to and maintaining of organic farming under the proposed CAP Pillar I eco-schemes, and include in agri-environment-climate commitments under Pillar II.

• Under the Farm Advisory Services (FAS), improve farmers' knowledge on OPB, breeding technologies accepable in organic, the new plant reproductive materials introduced in the EU Organic Regulation, and on variety registration (patents, IPR rights).

Member States can also consider boosting OPB via lowering the VAT rates for organic products deriving from organic plant reproductive materials, i.e. which are 100% organic.

Green public procurement (GPP) offers a great potential to boost organic plant breeding if procurement procedures consider small farms, micro-enterprises and SMEs that work with organic breeding materials and if organic products deriving from organically produced seed and breeding materials are integrated into the criteria for sustainable food public procurement.

OPB presents a valuable link to sustainable agriculture, ecosystem services, climate change mitigation and biodiversity in **corporate sustainability and social responsibility strategies**.

Organic farming and plant breeding should also be integrated in **financing schemes supporting natural capital development, pro-biodiversity and adaptation businesses** (as part of sustainable agriculture), at the EU level e.g. in The Natural Capital Financing Facility, EU Business@Biodiversity platform, EU carbon farming initiative, the multiannual financial framework 'Next Generation EU' which funds investments in the organic sector.

Involving actors in **participatory organic plant breeding** boosts social sustainability supporting the EU's Long-term Vision for Rural Areas. The **Bio Districts** concept could also integrate OPB and the planned **demonstration farm networks** set out in the EU Organic Action Plan, to facilitate participatory models of fostering knowledge development and integration with value chain, rural development actors and consumers.

Resources and further reading:

- Towards ecological and societal resilience through systems-based plant breeding
- Integration of OPB in value chain partnerships
- Input from organic breeders
- Novel breeding concepts and strategies for low input agriculture

About this policy brief

This brief is part of a series aiming to inform policy-makers on the key results of the LIVESEED project, and provide recommendations to based on research results. The systems-based breeding approach was developed as part of the work on innovative breeding strategies for organic agriculture (WP3). The series of LIVESEED Policy Briefs can be found at Policy Briefs | Liveseed.

Authors: Agnes Bruszik &Lili Barta (IFOAM Organics Europe), Edwin Nuijten (De Beersche Hoeve)

Contact: enuijten@yahoo.com; info@organicseurope.bio;

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