SYSTEMS-BASED BREEDING APPROACH:
HOW TO IMPLEMENT IT?

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OWC Preconference, 6 September 2021
Workshop program

15.30-16.00 Introduction
16.00-16.10 Questions
16.10-16.30 Personal exercise
16.30-16.50 Groupwork (in groups of two)
16.50-17.00 Discussion
Which steps are needed for implementing the systems-based breeding approach?

Describe:
- current trends in breeding
- solution pathways: systems-based breeding
- all relevant aspects of breeding and seed systems

Provide:
- methods for self-reflection
- methodology for group-reflection
- guidelines for other steps at value chain level
Current trends in agriculture and plant breeding

- Continuous focus on linear value chains
- More focus on molecular traits
- Loss of agro-biodiversity

Summary of distribution of variety registration at CPVO in the period 2012-2016, according to crop, company and country (Annual report 2016)

<table>
<thead>
<tr>
<th></th>
<th>arable crops</th>
<th>vegetable crops</th>
<th>fruit crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top 5 crops</td>
<td>69,4</td>
<td>67,2</td>
<td>60,9</td>
</tr>
<tr>
<td>Top 10 crops</td>
<td>85,3</td>
<td>79,5</td>
<td>81,4</td>
</tr>
<tr>
<td>Top 5 companies</td>
<td>47,0</td>
<td>69,3</td>
<td>22,2</td>
</tr>
<tr>
<td>Top 15 companies</td>
<td>63,5</td>
<td>95,3</td>
<td>43,6</td>
</tr>
<tr>
<td>Top 5 countries</td>
<td>63,5</td>
<td>94,2</td>
<td>39,9</td>
</tr>
</tbody>
</table>
How to breed for long term ecosystem-services?

Biodiversity and ecosystems services are key factors that contribute to:

• natural pest control
• **pollination**
• nutrient (re)cycling
• soil conservation (structure and fertility)
• water provision (quality and quantity)
• carbon sequestration

Enhancing legume ecosystems services through plant-pollinator interplay.
Suso et al. 2016
How to breed for long term ecosystem-services?

Biodiversity and ecosystems services are key factors that contribute to:

- natural pest control
- pollination
- nutrient (re)cycling
- soil conservation (structure and fertility)
- water provision (quality and quantity)
- carbon sequestration

Genetic variation in root biomass in grass (Lolium multiflorum). Deru et al. 2014

LiveSeed
Organic 3.0 (IFOAM 2015): Broadening the organic scope for 2030

Five dimensions:
- Ecology
- Society
- Culture
- Accountability
- Economy
SDGs of UN (2015) - targets for ecological and societal resilience
Six goals for future plant breeding for ecological AND societal resilience

1. Social justice
2. Food security, food quality and safety
3. Food and seed sovereignty
4. Agro-biodiversity
5. Ecosystem services
6. Climate robustness
Current state of the art: Four breeding orientations ('paradigm positions', styles of thought)

- Holism
  - Community-based breeding
  - Ecosystem-based breeding
- Subjectivism
- Objectivism
  - Corporate-based breeding
  - Trait-based breeding
- Reductionism
Need for balance, optimal interaction and synergy
Hence, a need for systems-based breeding approaches
Steps needed towards systems-based breeding:

Three categories of steps:

1. Required change in attitude
2. From attitude to action
3. From actions to achievements
Required change in attitude

Three key-elements:

1. Corporate Social Responsibility
2. Circular Economy & True Cost accounting
3. Fair & Green Policy
Example 1: Required change in attitude

Three key-elements
1. Corporate Social Responsibility
2. Circular Economy & True Cost accounting
3. Fair & Green Policy

Organic farmer breeder Frank Morton Oregon-USA

10% of turn-over of Frank’s free varieties to Seed Company High Mowing

This project received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 722730.
Example 2: Required change in attitude

- New resistant potato varieties were not adopted by the market and continuous (in NL illegal) copper use and harvest failures
- In 2017, in NL full commitment of all supermarkets achieved to sell only resistant cultivars for organic potato by 2020

Three key-elements:
1. Corporate Social Responsibility
2. Circular Economy & True Cost accounting
3. Fair & Green Policy
Example 3: Required change in attitude

Composite cross populations versus pure line varieties

Three key-elements

1. Corporate Social Responsibility
2. Circular Economy & True Cost accounting
3. Fair & Green Policy

(1) EU experiment (2014-2021) to allow heterogeneous material to be described and marketed

(2) Allowing changes in official Variety Testing protocols (VCU)
Three key-elements:
1. Knowledge development & Integration of knowledge
2. Breeding strategies & tools
3. Entrepreneurship
Example 2
From attitude to action

Breeding for diversity e.g. ‘heterogeneous material’ and crop mixtures

Three key-elements:
1. Knowledge development & Integration of knowledge
2. Breeding strategies & tools
3. Entrepreneurship

Composite cross populations:
► Multiple crosses

Crop mixtures (e.g. lupine/wheat):
► breeding for combinability

LIVESEED

This project received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 727230.
Example 3: From attitude to action

Three key-elements:

1. Knowledge development & knowledge integration
2. Breeding strategies & tools
3. New entrepreneurial models

100% employee owned
Example 3: From attitude to action

Three key-elements:

1. Knowledge Development & knowledge integration
2. Breeding strategies & Tools
3. New entrepreneurial models

Biodynamic Seed & Vegetable Farm
100% daughter of Food Cooperative Odin
From action to achievement: six goals for ecological and social resilience

Six key-elements (goals):

1. Social justice
2. Food security, quality and safety
3. Food and seed sovereignty
4. Agro-biodiversity
5. Ecosystem services
6. Climate robustness

Roles and positioning of breeding and seed systems within their economic, scientific, institutional and cultural environment (Figure 3, Lammerts van Bueren et al. 2018)
**Witzenhausen workshop 2018**: workshop outcomes organised according to the four categories as described in Figure 3 (Lammerts van Bueren et al. 2018)

<table>
<thead>
<tr>
<th>Category</th>
<th>Solutions (in %)</th>
<th>Obstacles (in %)</th>
<th>Examples (in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N =</td>
<td>85</td>
<td>68</td>
<td>39</td>
</tr>
<tr>
<td><strong>Market and Industry</strong></td>
<td>69</td>
<td>27%</td>
<td>37%</td>
</tr>
<tr>
<td><strong>Policy and Governance</strong></td>
<td>43</td>
<td>18%</td>
<td>32%</td>
</tr>
<tr>
<td><strong>Science and Technology</strong></td>
<td>51</td>
<td>33%</td>
<td>18%</td>
</tr>
<tr>
<td><strong>Societal and Cultural Norms and Values</strong></td>
<td>29</td>
<td>22%</td>
<td>13%</td>
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## Key elements

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<tr>
<th>Required change in attitude</th>
<th>Corporate social responsibility</th>
<th>Circular economy &amp; True cost accounting</th>
<th>Fair &amp; green policy</th>
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<td>From attitude to action</td>
<td>Knowledge development and integration</td>
<td>Breeding strategies and tools</td>
<td>Entrepreneurship</td>
</tr>
<tr>
<td>From action to achievement</td>
<td>Food security, safety &amp; quality</td>
<td>Food &amp; seed sovereignty</td>
<td>Social justice</td>
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<tr>
<td></td>
<td>Agrobiodiversity</td>
<td>Ecosystem services</td>
<td>Climate robustness</td>
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</table>

### Tool for self reflection: applying 12 key elements in an assessment

Spider chart per company/initiative:

- **Agro-biodiversity**
- **Climate robustness**
- **Ecosystem services**
- **Food & seed sovereignty**
- **Food security, quality & safety**
- **Social justice**
- **Circular economy**
- **Breeding tools**
- **Knowledge development &...**
- **Entrepreneurship**

This project received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 772730.
For circular economy we need rebuilding of linear value chains: towards circular organised food systems

.....including breeders as partners in new ‘food communities’
......including shared risk taking to overcome individualism.
Lessons learned from DIVERSIFOOD on multi-actor processes: reflection in a group process especially with respect to technical and social aspects

Reflection in a group process
- Involve various actors of the value chain;
- Make the implicit explicit;
- What are our assumptions?
  - We are often unaware of them
  - The perspectives of each actor can be different;

Adapted scheme of Figure 7, Deliverable 1.3, EU-Project DIVERSIFOOD
Biofach workshop 2019: systems-based approach in organic plant breeding: integration into value chain partnerships

• Main questions remained to address collectively:
  • Why should different value chain actors support organic plant breeding?
  • The advantage of organic plant breeding for value chain (farmer, processors, traders)
  • The advantage of organic plant breeding for consumers and society (local and global)

• Tailor-made approaches are needed
  • Needs to include new approaches for: knowledge exchange, communication, marketing, education, etc
The importance of a systems-based approach

• Fostering diversity in breeding approaches and breeding initiatives helps:
  • maintain agrobiodiversity
  • make agriculture more climate robust
  • foster the development and maintenance of knowledge
  • develop new types of relationships
  • keep an open mind on what seeds are: part of our common heritage