Workshop on system based breeding with Sativa and GZPK and hosted by FiBL

Edith Lammerts van Bueren ¹,² & Edwin Nuijten ¹,³

¹Louis Bolk Institute, NL
²Wageningen University, NL
³Beersche Hoeve, NL

Frick, 16 April 2019
Trend 1: increasing trait-based breeding

More and more plant breeding is becoming trait breeding
Trend 1: Trait breeding

More and more plant breeding is becoming trait breeding

Systems breeding

Plant breeding

Trait breeding
Trend 1: Trait breeding

More and more plant breeding is becoming trait breeding and Systems breeding. How to incorporate that into current breeding?
Trend 2: Loss of small crops in breeding

- National diets are becoming more diverse, worldwide diets are increasingly more similar (Khoury et al. PNAS 2014).
- Of the 30,000 edible species we grow only 150,
- 95% of our human food calories originate from 30 crop species (WHO & CBD, 2015)
- Mergers in the breeding sector
  - Loss of diversity in breeding programs
  - Small crops are orphans in breeding
  - Both commercial and public breeding programs are not focused on food diversity
Trend 2: Loss of small crops in breeding

- National diets are becoming more diverse, worldwide diets are increasingly more similar (Khoury et al. PNAS 2014).
- Of the 30,000 edible species we grow only 150,
- 95% of our human food calories originate from 30 crop species (WHO & CBD, 2015)
- Mergers in the breeding sector
  - Loss of diversity in breeding programs
  - Small crops are orphans in breeding
  - Both commercial and public breeding programs are not focused on food diversity

Who cares? 

LIVESEED
Trend 3: Breeding for (longterm) ecosystems 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
Trend 3: Breeding for (longterm) ecosystems services?

Biodiversity and ecosystems services are key to contribute to:
• natural pest control
• pollination
• nutrient (re)cycling
• soil conservation (structure and fertility)
• water provision (quality and quantity)
• carbon sequestration

...in turn contributing to food security and quality!
Trend 3: Breeding for (longterm) ecosystems 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
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. Euphytica 2014
Trend 3: Breeding for (longterm) ecosystems services?

Where is the breeding business?
Trend 4: Organic 3.0 (IFOAM 2015): Broadening the organic scope for 2030

Five dimensions:
- Ecology
- Society
- Culture
- Accountability
- Economy
Trend 4: Organic 3.0 (IFOAM 2015): Broadening the organic scope to 2030

Five dimensions:
• Ecology
• Society
• Culture
• Accountability
• Economy

How to transform those criteria into breeding?
Trend 5: SDGs of UN (2015) - targets for ecological and societal resilience
Trend 5: SDGs of UN (2015) - targets for ecological and societal resilience

How to transform those criteria into breeding?
Six goals for plant breeding for ecological AND societal resilience

1. Social justice
2. Food security, food quality and food safety
3. Food and seed sovereignty
4. Agro-biodiversity
5. Ecosystem services
6. Climate robustness
Framework of analysis
(adapted after Bawden, 2010)
Current state of the art: Four breeding orientations (‘paradigm positions’ or ‘styles of thinking’)

- **Holism**
  - Community-based breeding
  - Ecosystem-based breeding

- **Subjectivism**
  - Corporate-based breeding

- **Objectivism**
  - Trait-based breeding

- **Reductionism**

**LiveSeed**

This project received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 777230.
Four breeding orientations

- Community-based breeding
- Ecosystem-based breeding
- Corporate-based breeding
- Trait-based breeding

Holism vs. Objectivism
Subjectivism vs. Reductionism

LIVESEED

This project received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 722290.
Four breeding orientations

- Community-based breeding
- Ecosystem-based breeding
- Corporate-based breeding
- Trait-based breeding

Holism

Subjectivism

Objectivism

Reductionism

This project received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 777230.
Four breeding orientations

- Community-based breeding
- Corporate-based breeding
- Ecosystem-based breeding
- Trait-based breeding

- Holism
- Subjectivism
- Objectivism
- Reductionism

This project received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 772230.
Four breeding orientations

- Community-based breeding
- Corporate-based breeding
- Subjectivism
- Objectivism

- Holism
- Ecosystem-based breeding
- Trait-based breeding
- Reductionism

This project received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 777230.
Each have strengths and weaknesses

- **Holism**
  - Community-based breeding
  - Ecosystem-based breeding

- **Subjectivism**
  - Corporate-based breeding

- **Objectivism**
  - Trait-based breeding

- **Reductionism**

---

**LIVESEED**

This project received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 727230.
Each have strengths and weaknesses

Holism

Community-based breeding

Subjectivism

Trait-based breeding

Objectivism

Reductionism

But none, alone or even in two- or three way interactions, can reach all six goals...!
Need for optimal interaction and synergy
Need for optimal interaction and synergy

To avoid locked-in situations...!
5th breeding orientation needed: systems-based breeding
5th orientation: systems-based breeding

'System': civil society, policy, nature, agriculture, and value chains and markets as interrelated and mutually dependent components of the entire system.
5th orientation: systems-based breeding

This style of thought is systems-centric by its focus and by its methodology; requires system thinking of all actors; all parts are interrelated and affecting each other.

All partners should commit themselves to a collective learning process to achieve this shift!
Required change in attitude

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

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
From linear to circular organised value chains or food communities

• More and more specialisation in the value chain.
• Even when each partner would do it’s ultimate best to become sustainable,
• Still it is easy to throw aspects over the fence,
• And then we get ‘organised irresponsibility’………

• Even organic value chains are still traditionally linear organised....!
How can we build true relationships?

Towards circular organised value chains:

.....including breeders as partners in food communities.
From attitude to action

Three key-elements form attitude to action:

1. Knowledge Development & Integration
2. Breeding strategies & Tools
3. Entrepreneurship
Example 1: From attitude to action

Three key-elements form attitude to action:

1. Knowledge Development & Integration
2. Breeding strategies & Tools
3. Entrepreneurship

Organic farmer breeder Frank Morton Oregon-USA

10% turn over of Frank’s free varieties
Example 2: From attitude to action

Three key-elements:
1. Knowledge Development & Integration
2. Breeding strategies & Tools
3. Entrepreneurship

100% employee owned
From action to achievement: 6 goals

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
From action to achievement: 6 goals

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

Four P’s!
People, planet, profit and purpose

LIVESEED
From action to achievement: 6 goals

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
12 Key-elements of systems-based breeding: as an assessment tool

- Agro-biodiversity
- Food & seed sovereignty
- Food security, quality and safety
- Social justice
- Circular economy
- Corporate social responsibility
- Entrepreneurship
- Knowledge development & Integration
- Climate robustness
- Ecosystem services
- Fair and green policy
- Food security, quality and safety
- Food & seed sovereignty

Spider chart per company/initiative:

- Agro-biodiversity
- Food sovereignty
- Food security and safety
- Social justice
- Circular economy
- Corporate social responsibility
- Knowledge development
- Entrepreneurship
- Climate robustness
- Ecosystem services
- Fair and green policy

This project received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 727730.
Acknowledgements

• The scientific paper underlying this concept is: *Lammerts van Bueren E.T., Struik P.C., Van Eekeren N., Nuijten E. Towards resilience through systems-based plant breeding. A review. Journal of Agronomy for Sustainable Development (2018) 38: 42 (open access)*

• This concept is developed under EU project LIVESEED (2017-2021) and will be further elaborated!