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EXCELLENCE FOR SUSTAINABILITY

ECO·PB European Consortium for Organic Plant Breeding

Research Institute of Organic Agriculture
Forschungsinstitut für biologischen Landbau
Institut de recherche de l'agriculture biologique





Advances in Organic Plant Breeding

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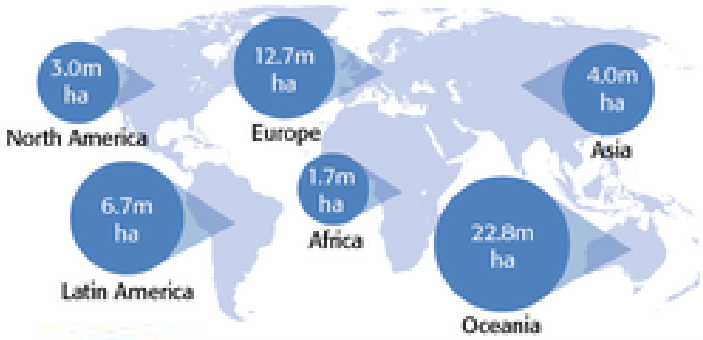
European Consortium for Organic Plant Breeding (ECO-PB) www.eco-pb.org

Member of IFOAM_EU Seed Expert Group & IFOAM International Seed Platform

Global Forum for Innovations in Agricultural Utrecht, 10th May 2017

The World of Organic Agriculture 2015

Organic Land 2015



50.9m ha Organic farmland

179 Countries with organic farming

+14.7% From 2014

Organic Producers 2015

Number of organic producers is increasing

2.4 million Organic farmers

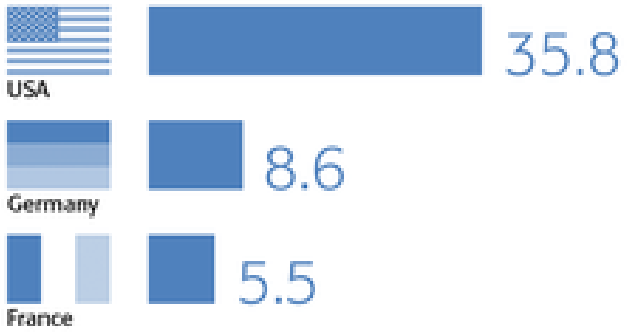
+7.2% From 2014

Organic Market 2015

The global market is growing and consumer demand is increasing

Approx. 75 Global organic food market in billion euros

Top 3 countries (market in billion euros)



FiBL Survey 2017 based on national sources
www.organic-world.net/yearbook/yearbook- 2017.html

Why we need Organic Plant Breeding and new Concepts?

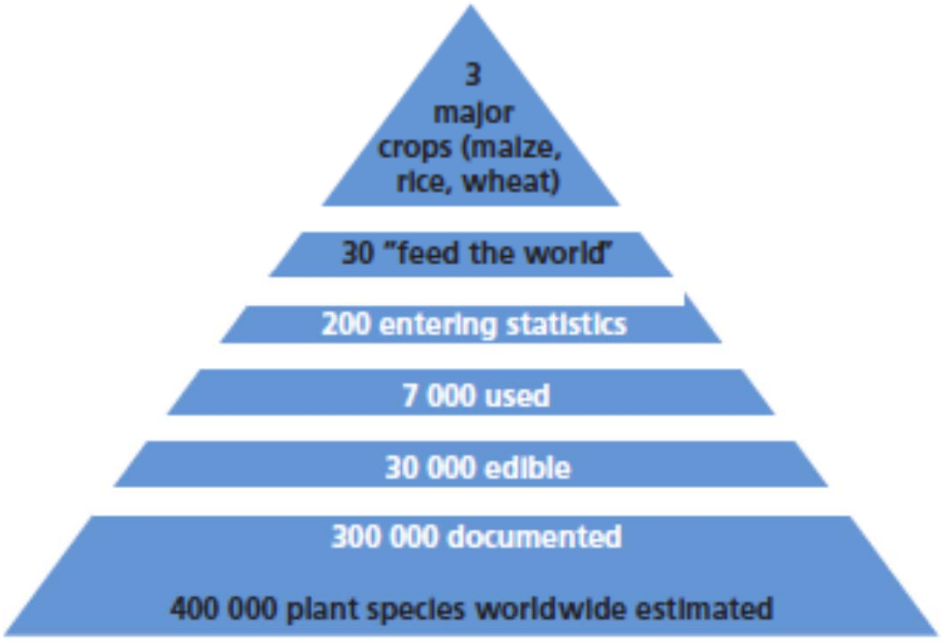
- **Ecological instensification of organic production through**
  - Focused breeding for **target environments** with limited external inputs
  - Selection for **specific traits**, like seed- borne diseases, weed competition
  - Meeting market demand and **expectation of farmers and consumer**
  - **Alternative breeding programs** refraining from genetic engineering and certain breeding techniques

- **Enabling more sustainable food production systems through**
  - **Large portfolio of crops on farm level** to mitigate risks of crop failure
  - **Functional biodiversity on field level** to reach high level of self regulation and closed nutrient cycle
  - Safeguarding and **evolving genetic resources** for future generations

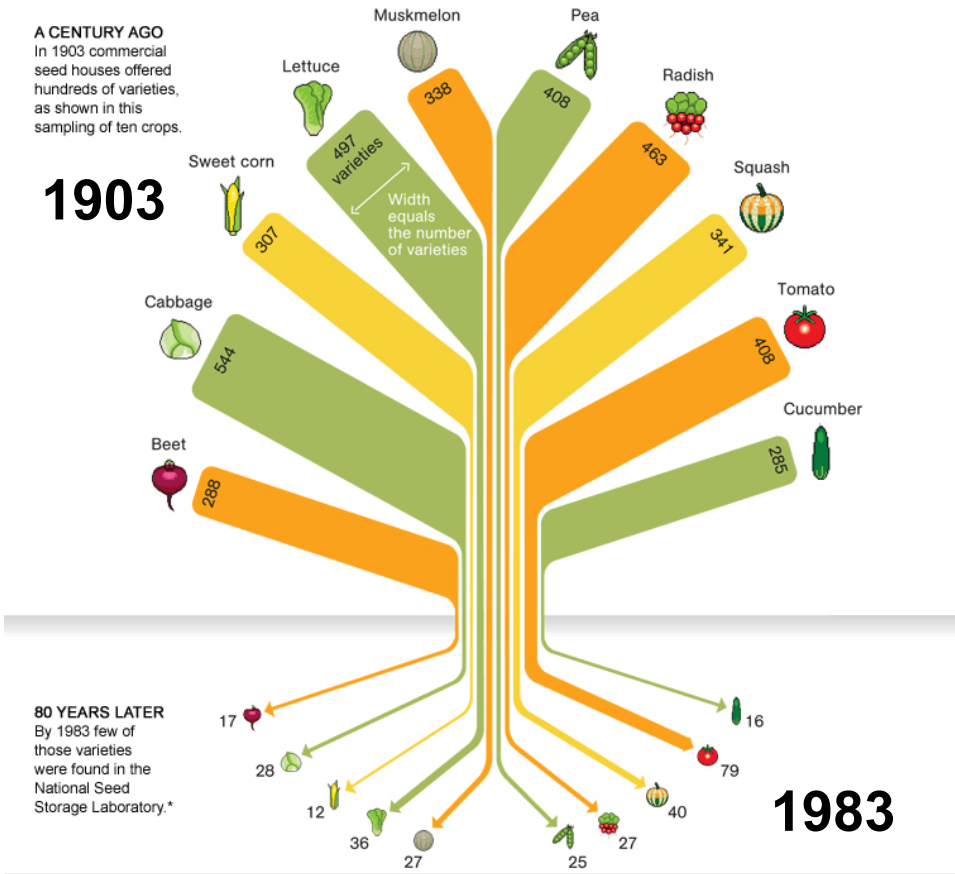
Reduced number of crops and cultivar per crops

FIGURE 5.1

Use of crop species diversity in agriculture



Source: FAO, 1996



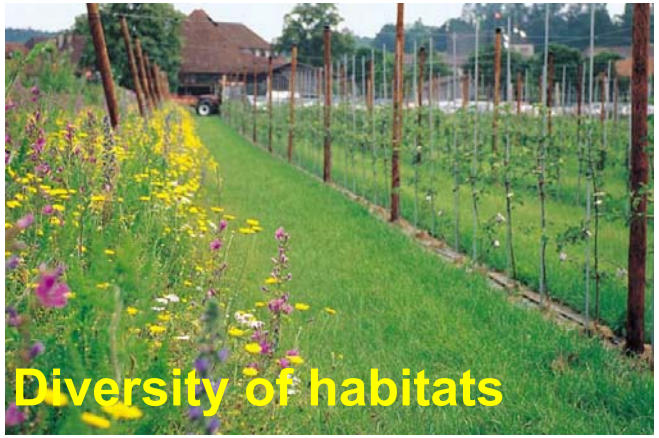
John Tomanio, NGM Staff Food Icons, Quickhoney, Source Rural Advancement Foundation International

Strategies for Organic Plant Breeding

- Combining **breeding & agronomic innovations under organic conditions**
- Breeding for **increased diversity**
  - Breeding for diversity within cultivars
  - Breeding for mixed cropping systems
  - Breeding for improve diversity of associated soil microbes
  - Decentralized participatory breeding for local conditions

- **Embedding diversity into markets**
  - **Involving all stakeholders** (farmer, value chain and community driven breeding)
  - New concepts for the **ownership** of cultivars and their financing
  - Changing **regulatory framework** to foster greater agrobiodiversity (official variety testing, seed regulation)
  - **Valorization** of organic plant breeding along the value chain (www.bioverita.org)

Breeding for functional biodiversity

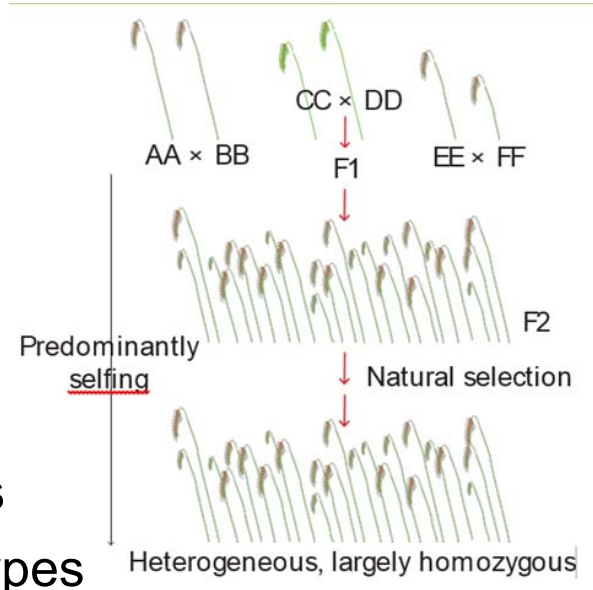


Fotos: FiBL

Breeding for improved diversity within cultivars

Composite Cross Populations / Evolutionary populations

- «Heterogeneous material» derived from multiparental crosses
- Mixture of many different genotypes that evolve over time



Advantage of heterogeneous compared to uniform cultivars

- Higher yield stability due to compensation between different genotypes
- Lower disease and pest pressure
- Less prone to abiotic stress (heat, drought, fooding, freezing temperature)
- Evolutionary adaptation to local growing conditions (larger root systems under organic)

Döring et al. 2011 Evolutionary Plant Breeding in Cereals – Into a New Ear, Sustainability 3:1944.1971

Raggi et al. 2017 Evolutionary breeding for sustainable agriculture: Selection and multi-environmental evaluation of barley populations and lines, Field Crops Research, 204: 76-88

Breeding for mixed cropping systems

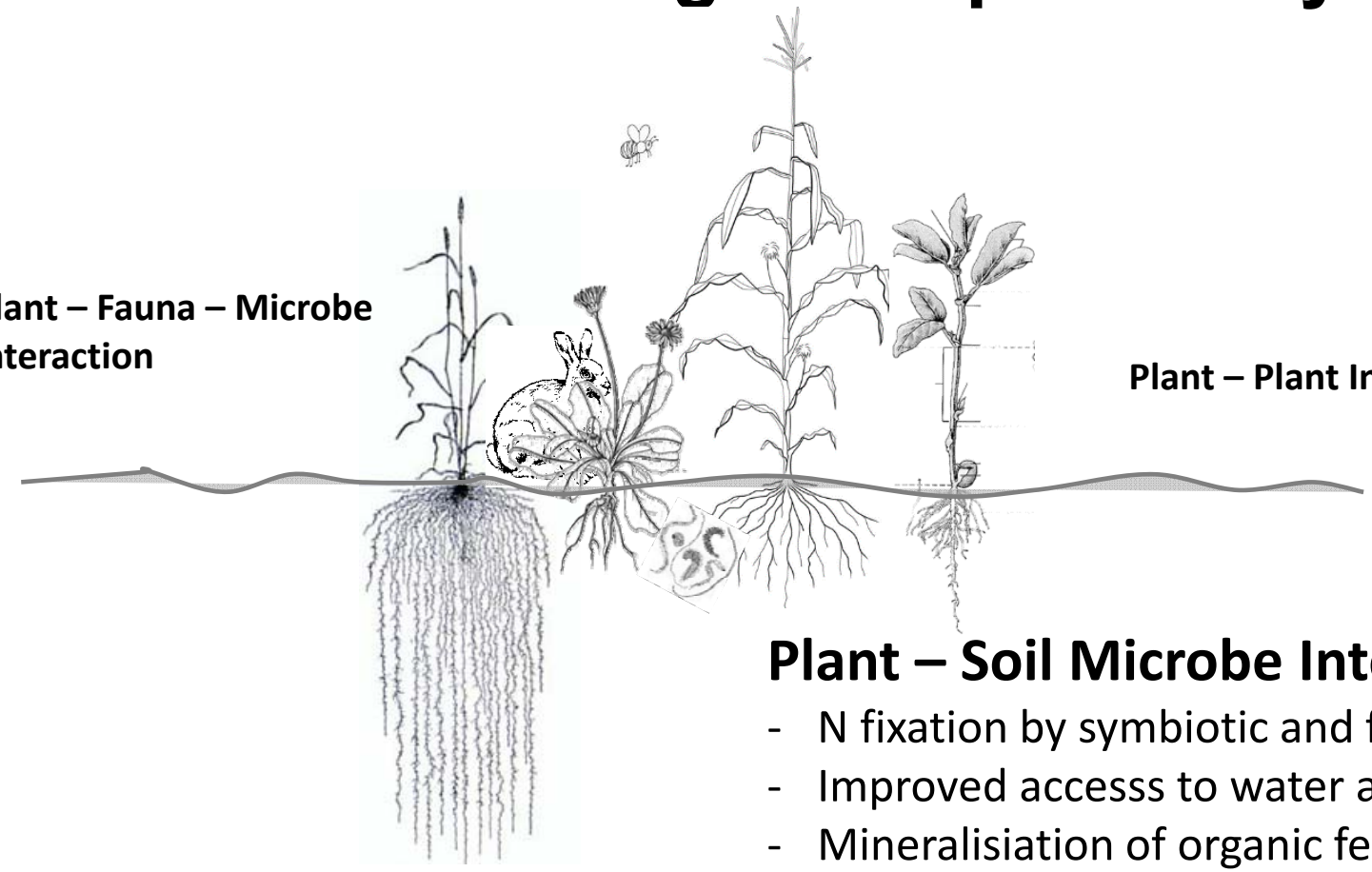
Advantage of species mixtures

- Improved productivity per area compared to monoculture
- Improved biological nitrogen fixation in legume cereal mixtures compared to legume monocrops (source sink of N)
- Complementary requirements of available resources
- Compensation of companion crop if one crop fails

Breeding research

- Identification of complementary crossing partners
- Identification of traits responsible of high performance in mixture
- Determination of general and specific mixing ability
- Develop efficient breeding strategies for mixtures combined with agronomic and technical innovations

Breeding for improved symbiosis



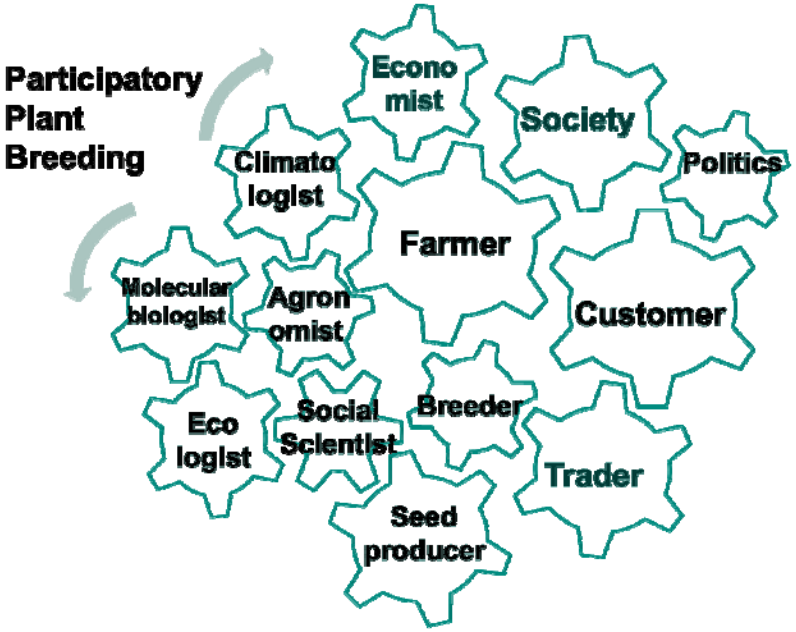
Plant – Fauna – Microbe Interaction

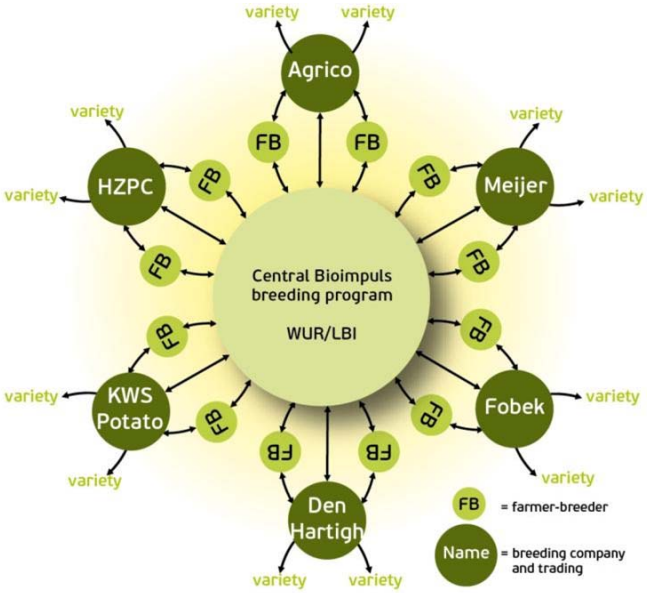
Plant – Plant Interaction

Plant – Soil Microbe Interaction

- N fixation by symbiotic and free living bacteria
- Improved accesss to water and nutrients by mycorrhiza
- Mineralisiation of organic fertilizer
- Root exudation
- Plant growth promoting rhizobacteria (PGPR)
- Pathogenes & counterparts

Decentralized Participatory Plant Breeding





- **Bioimpuls Programme 2009-2013: Perspectives on Phytophthora-resistant potato varieties,** *Lammerts van Bueren et. al. 2013 Broshure*
- **Participatory tomato breeding for organic conditions in Italy;** *Campanelli et a. 2015 Euphytica DOI 10.1007/s10681-015-1362;*
- **GM Crops, Organic Agriculture and Breeding for Sustainability,** *Ceccarelli (2014) Sustainability 6, 4273-4286, DOI 10.3390/su6074273*

European Projects to promote new Breeding Concepts

- FP7 **Solibam**: Strategies for Organic and Low-input Integrated Breeding and Management www.solibam.eu 2010-2014
- Core organic **COBRA**: Coordinating organic plant breeding activities for diversity www.cobra-div.eu 2013-2016
- Horizon 2020 **DIVERSIFOOD**: Embedding crop diversity and networking for local high quality food systems, www.diversifood.eu 2015-2019
- New Horizon 2020 **LIVESEED** : Improve performance of organic agriculture by boosting organic seed and plant breeding efforts across Europe 2017-2021
- New Horizon 2020 **ReMIX**: Redesigning European cropping systems based on species MIXtures 2017-2021

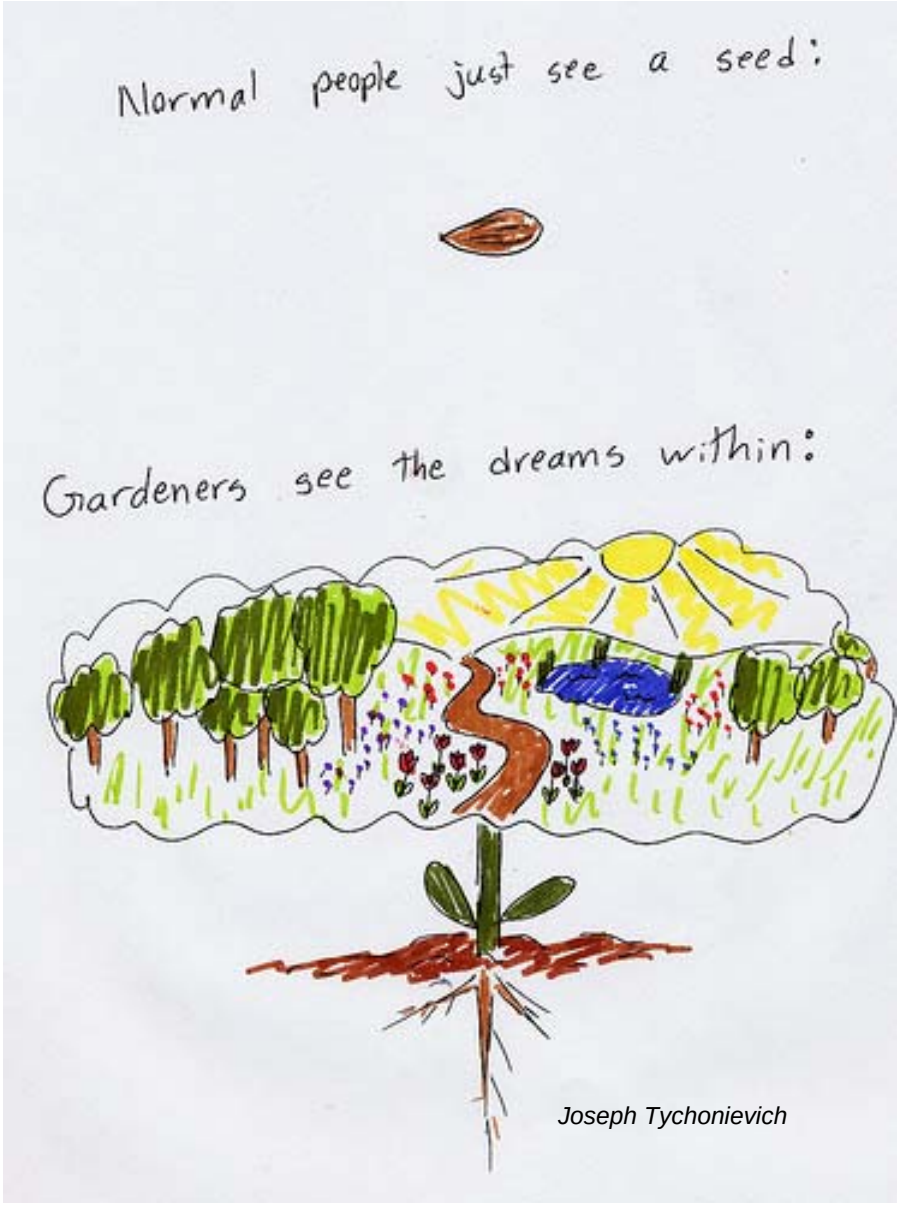
Criteria for Organic Plant Breeding

Ethical issues

- **Genom** is respected as indivisible entity, no technical/physical intervention (e.g. isolated DNA)
- **Cell** is respected as indivisible **functional entity**, no technical/physical intervention (e.g. cell fusion)
- Maintain **reproducibility** in species specific manner
- No legal or technical barriers to restrict **breeders' right**
- Natural **crossing barriers** are respected
- Promotion of **open pollinated varieties** as alternative to F1 hybrids to enable farm saved seed
- **Transparency**

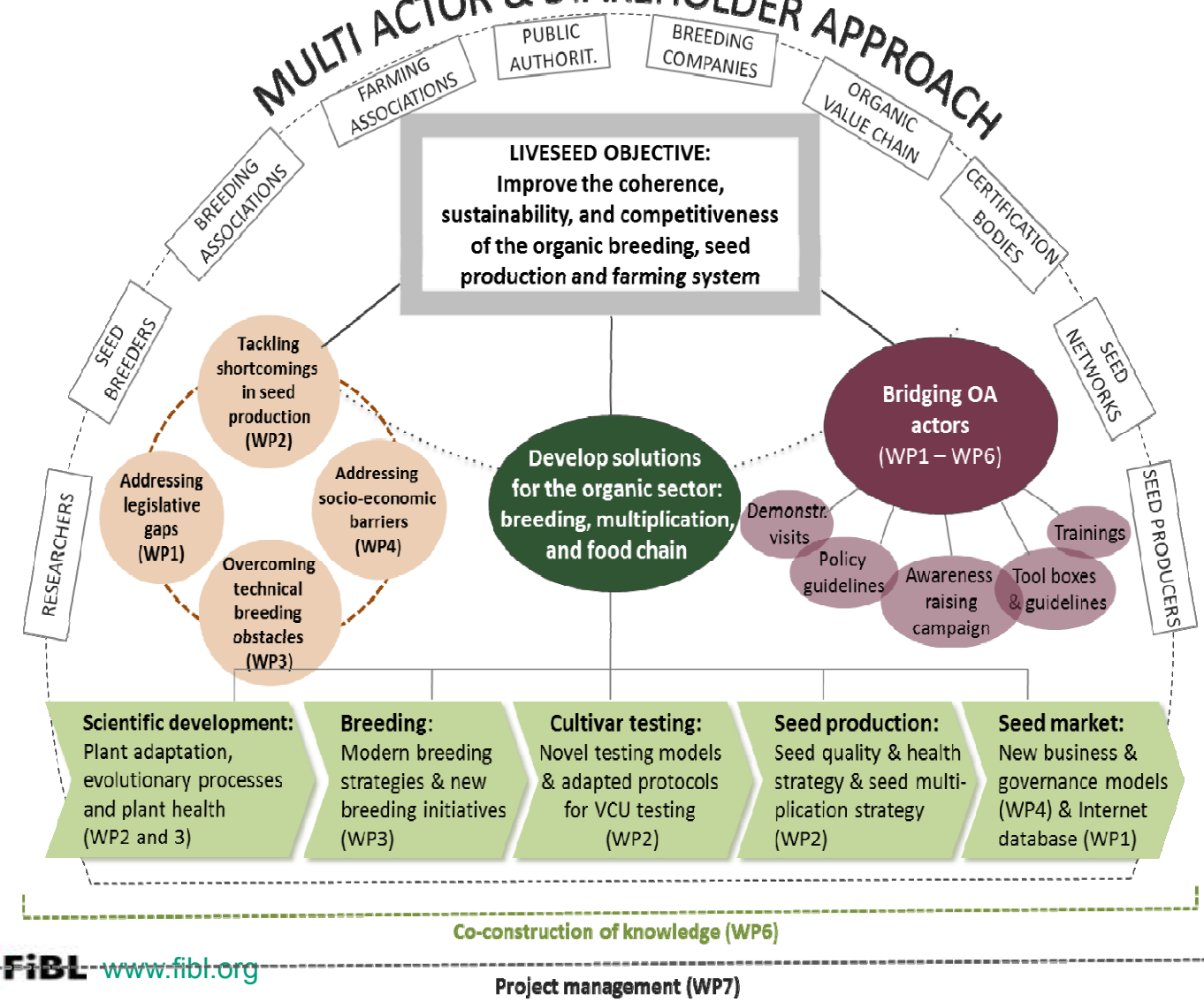
Position of the Organic Sector on the complience of New Breeding Techniques (NBT)

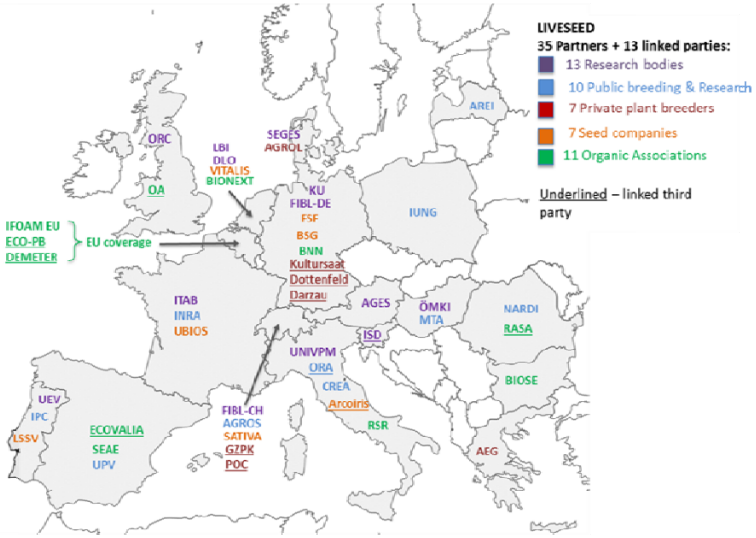
- **Position Paper of ECO-PB on Organic Plant Breeding 2013:**
  - Organic plant breeders in Europe will refrain from any breeding technique that technically interfers below the cell level
  - www.eco-pb.org/fileadmin/ecopb/documents/ecopb_PostitionPaperOrganicPlantBreeding.pdf
- **IFOAM EU Position Paper on New Plant Breeding Techniques 2015:**
  - NBT are not compatible with organic farming
  - Should be declared as GMO according to EU regulation and labelled accordingly
  - http://www.ifoam-eu.org/fr/file/position-paper-new-plant-breeding-techniques
- **IFOAM International: Position Paper on New Breeding Techniques in process**
  - Draft February 2017, Consultation till March 2017, Final approval on General Assembly of IFOAM in November 2017
  - **Transparency & traceability to allow freedom of choice for farmers & consumers**



Thanks a lot for your attention

LIVESEED


MULTI ACTOR & STAKEHOLDER APPROACH
FARMING ASSOCIATIONS
PUBLIC AUTHORIT.
BREEDING COMPANIES
ORGANIC VALUE CHAIN
CERTIFICATION BODIES
SEED NETWORKS
SEED PRODUCERS
RESEARCHERS
SEED BREEDERS
BREEDING ASSOCIATIONS
LIVESEED OBJECTIVE:
Improve the coherence, sustainability, and competitiveness of the organic breeding, seed production and farming system
Tackling shortcomings in seed production (WP2)
Addressing legislative gaps (WP1)
Addressing socio-economic barriers (WP4)
Overcoming technical breeding obstacles (WP3)
Develop solutions for the organic sector: breeding, multiplication, and food chain
Bridging OA actors (WP1 – WP6)
Demonstr. visits
Policy guidelines
Awareness raising campaign
Tool boxes & guidelines
Trainings
Scientific development: Plant adaptation, evolutionary processes and plant health (WP2 and 3)
Breeding: Modern breeding strategies & new breeding initiatives (WP3)
Cultivar testing: Novel testing models & adapted protocols for VCU testing (WP2)
Seed production: Seed quality & health strategy & seed multi-plication strategy (WP2)
Seed market: New business & governance models (WP4) & Internet database (WP1)
Co-construction of knowledge (WP6)
Project management (WP7)

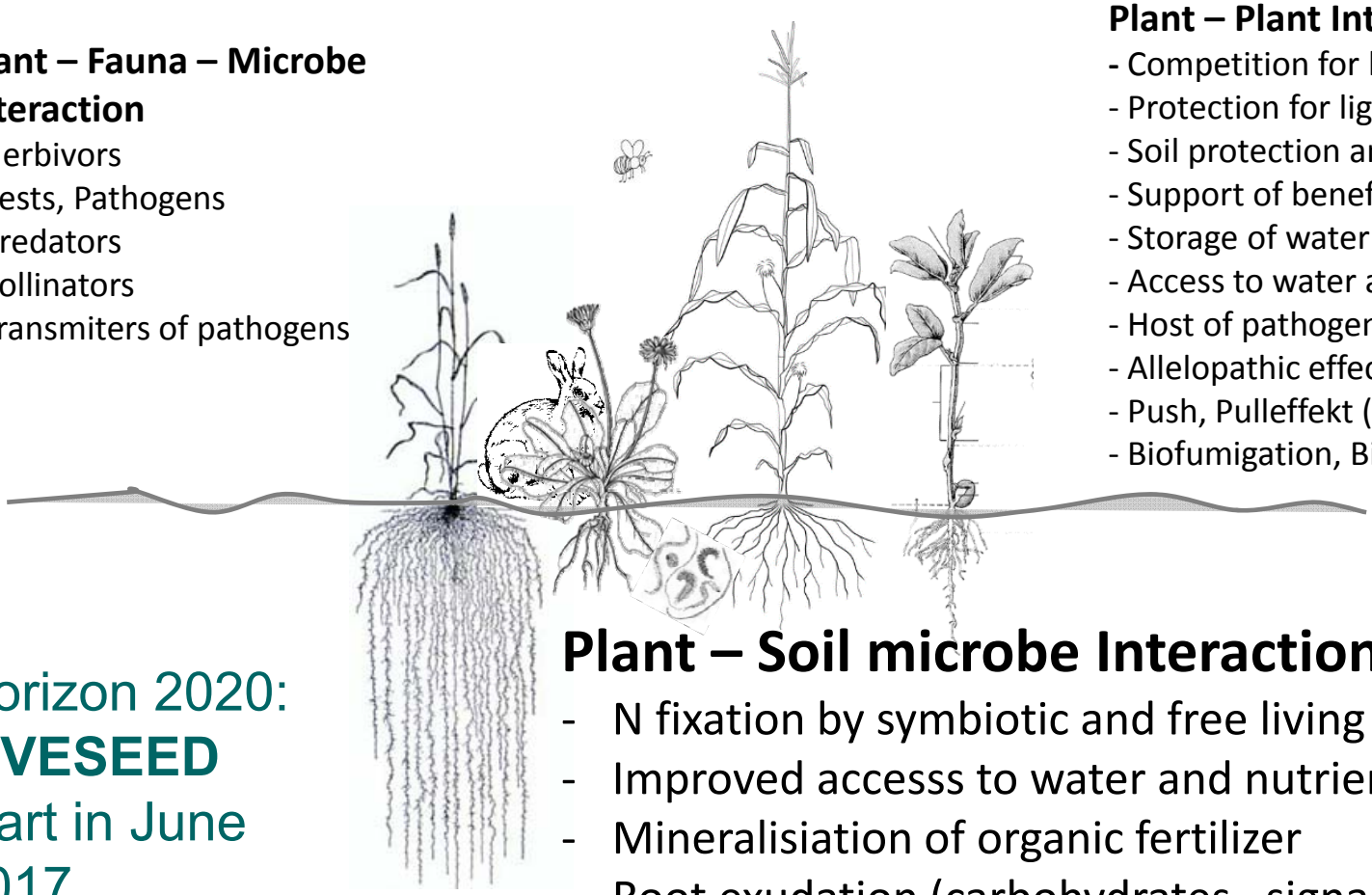

LIVESEED
35 Partners + 13 linked parties:
13 Research bodies
10 Public breeding & Research
7 Private plant breeders
7 Seed companies
11 Organic Associations
Underlined – linked third party
IFOAM EU
ECO-PB
DEMETER
EU coverage
ORC
OA
LBI
DLO
VITALIS
BIONEXT
SEGES AGROL
AREI
KU
FIBL-DE
FSF
BSG
BNN
Kultursaat
Dottenfeld
Darzau
IUNG
ITAB
INRA
UBIOS
AGES
ÖMKI
MTA
NARDI
RASA
ISD
UNIVPM
ORA
CREA
Arcoiris
BIOSE
UEV
IPC
LSSV
ECOVALIA
SEAE
UPV
FIBL-CH
AGROS
SATIVA
GZPK
POC
RSR
AEG

Requirements for organic farming

- Varieties adapted to organic farms, which produce **high and stable** yields with a **high quality** even under low-external input conditions
- Special requirements to the varieties:
  - Fast youth development
  - Nutrient efficiency (slow releasing fertilizer)
  - Capability of weed suppression or tolerant against weeds/weeding
  - Resistant towards seed born diseases
  - Utilization of symbioses with soil organisms
- Possibility of farm saved seeds
- Genetic diversity
- Prohibition of GMO (incl. cell fusion)
- Preservation and free access to GMO free genetic resources

Breeding for improved symbiosis

Plant – Fauna – Microbe Interaction
- Herbivors
- Pests, Pathogens
- Predators
- Pollinators
- Transmiters of pathogens



Plant – Plant Interaction
- Competition for light, water, nutrients
- Protection for light, wind, transpiration
- Soil protection and erostion prevention
- Support of beneficial insects
- Storage of water and nutrients
- Access to water and nutrients in deeper horizons
- Host of pathogens
- Allelopathic effects
- Push, Pulleffekt (Desmodia, Napiergras)
- Biofumigation, Biosanitation

Plant – Soil microbe Interaction
- N fixation by symbiotic and free living bacteria
- Improved accesss to water and nutrients by mycorrhiza
- Mineralisiation of organic fertilizer
- Root exudation (carbohydrates, signalling effects, attraction, repellents)
- Plant growth promoting rhizobacteria (PGPR)
- Pathogenes & counterparts

Horizon 2020:
LIVESEED
start in June 2017

FiBL www.fibl.org

ResPEAct: Improving disease resistance of pea through selection at the plant-soil interface

- Develop soil based screening system for complex of pathogens causing soil fatigue in pea
- Identify QTL and candidate genes involved in disease tolerance by genome-wide association studies
- Determine root exudate profiles
- Analyse key pathogens and beneficials using qPCR
- Determine genotype dependent soil microbial communities by New Generation Sequencing
- Elucidate importance of the holobiont (the plant host plus all of its symbiotic microbes) as selection target to improve plant health

New Breeding Techniques and Organic Farming ???

- ***Why Organic Farming Should Embrace Co-Existence with Cisgenic Late Blight–Resistant Potato***, *Godelieve Gheysen [1,*] & René Custers [2] Sustainability 2017, 9(2), 172*
- ***Concepts and Strategies of Organic Plant Breeding in Light of Novel Breeding Techniques**, Edwin Nuijten, Monika M. Messmer & Edith T. Lammerts van Bueren, Sustainability 2017, 9(1), 18;*
- ***Should Organic Agriculture Maintain Its Opposition to GM?** New Techniques Writing the Same Old Story, by Fern Wickson, Rosa Binimelis & Amaranta Herrero,Sustainability 2016, 8(11), 1105;*
- ***Are we ready for back-to-nature crop breeding?** Michael G. Palmgren, Anna Kristina Edenbrandt, Suzanne Elizabeth Vedel, Martin Marchman Andersen, Xavier Landes3, Jeppe Thulin Østerberg, Janus Falhof, Lene Irene Olsen, Søren Brøgger Christensen, Peter Sandøe, Christian Gamborg, Klemens Kappel, Bo Jellesmark Thorsen, & Peter Pagh, Trends in Plant Science (2014) 1–10*
- ***Towards social acceptance of plant breeding by genome editing**, Motoko Araki and Tetsuya Ishii, Trends in Plant Science, March 2015, Vol. 20, No. 3 145*