Varieties for organic production

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Organic agriculture: 4 Basic Principles

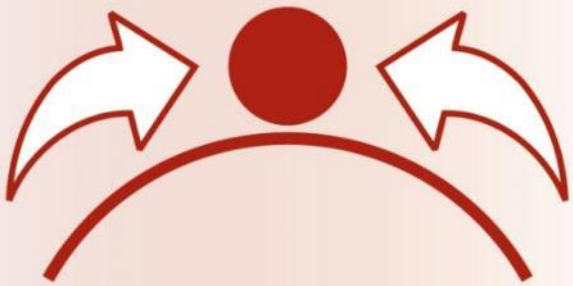
Organic agriculture is often known as:

- No chem-synthetic fertilisers
- No chem-synthetic pesticides, fungicides and herbicides
- No GMOs

www.ifoam.bio

Control versus Resilience model

Risk management model



- Risk oriented
- Eliminate variability
- Continuous monitoring and direct intervention
- High long-term risk
- Static equilibrium

Resilience model

- System oriented
- Make use of variability
- Enhance self-regulating capacity and indirect management
- Low long-term risk
- Dynamic equilibrium

(After Ten Napel et al. 2006)

Systems approach: multipurpose varieties

for food & feed

for straw, compost

for weed suppression

for soil structure

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Why organic plant breeding?

- Organic agriculture (OA) is in development and requires improved varieties that are better adapted to the ecological and ethical principles of OA.

  ►► Varieties that allow the organic system to work!

- The fact that organic growers use modern, 'conventional' varieties does not mean that they are the best to optimise organic farming systems

Sources for organic seeds (*Wolfe et al. 2009*)

1. Conventional breeding programs

2. Breeding <u>for</u> organic agriculture:
   partly in conv. selection fields (e.g. F1-F5)
   and partly in organic fields (e.g. F6-F8)

3. Breeding <u>in</u> organic agriculture:
   programs completely
   under organic production

bioverita
Seed of organically bred varieties

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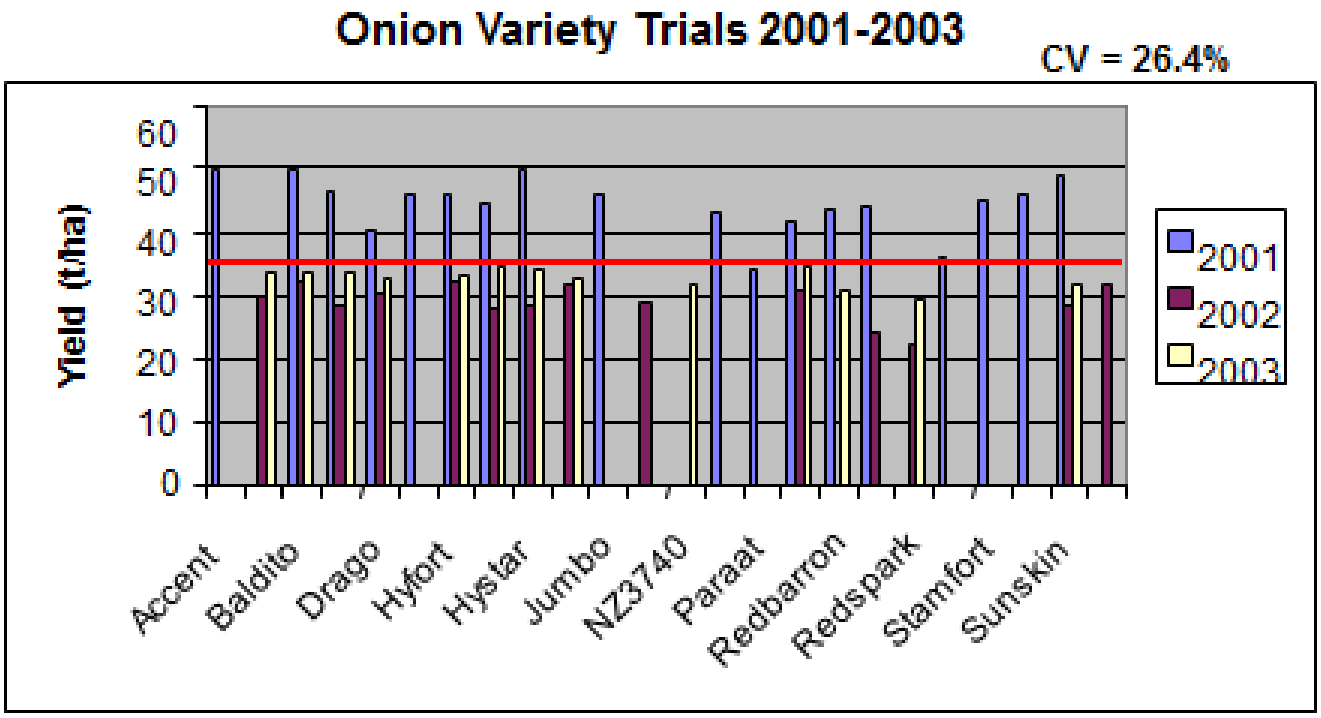
Summary table of traits for adaptation to low-external input systems

Management	**Breeding**
No mineral, but lower level of organic, slow releasing fertilizers	Nutrient efficiency Early vigor Explorative root system
No herbicides and need to reduce weed control labor	Weed suppression and weed competitiveness Early vigor
No pesticides and fungicides	High level of resistance Induced resistance Genetic variation
No GMOs	Advanced classic breeding methods in combination of MAS
Less means to mask environmental variation	Required varietal characteristics: Yield stability, Robustness, flexibility

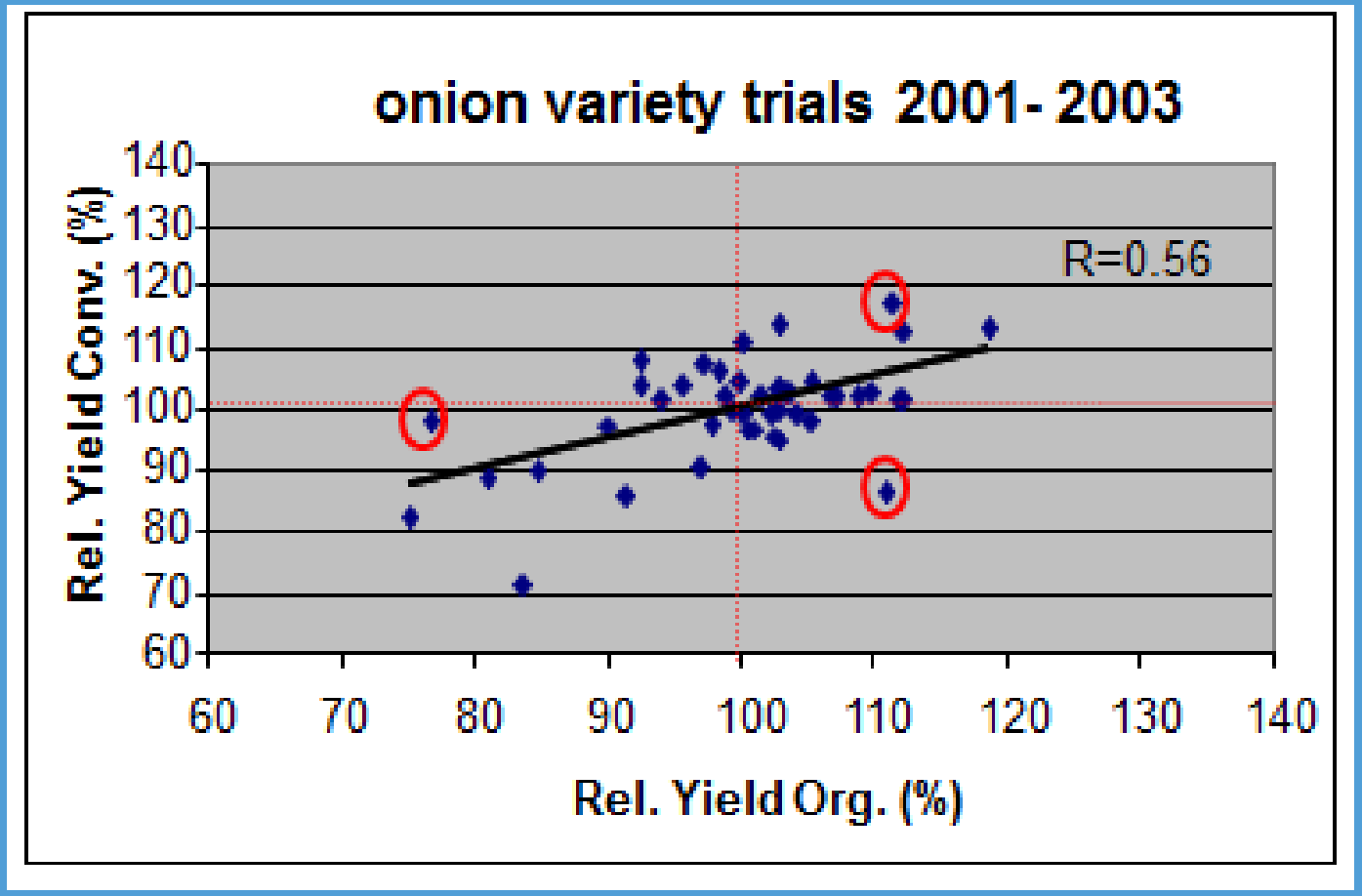
Yield and yield stability in organic onion production (due to downey mildew)



⇒
- year effects
- variety effects

CV = Coefficient of variation (%) is the variability over years (standard deviation/average yield)

Correlation between yield in organic and conventional agriculture



Changes of ranking under organic and conventional growing conditions

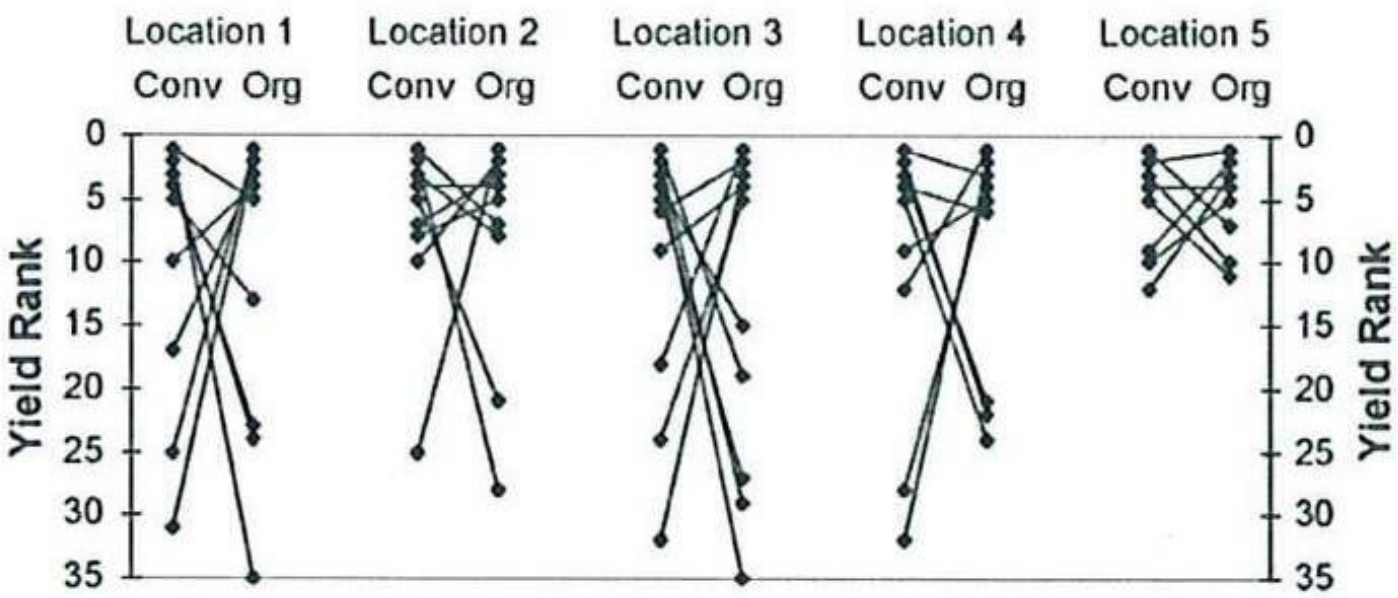


Fig. 1. Genotypic change in rank between organic and conventional wheat nurseries. The top five ranking genotypes for yield in both organic and conventional systems were compared at each location. Genotypes are ranked from 1 = highest yield to 35 = lowest yield.

(Murphy et al. 2007)

Nitrogen use efficiency (NUE) in cabbage

150 kg N/ha (left) and 300 kg N/ha (right)

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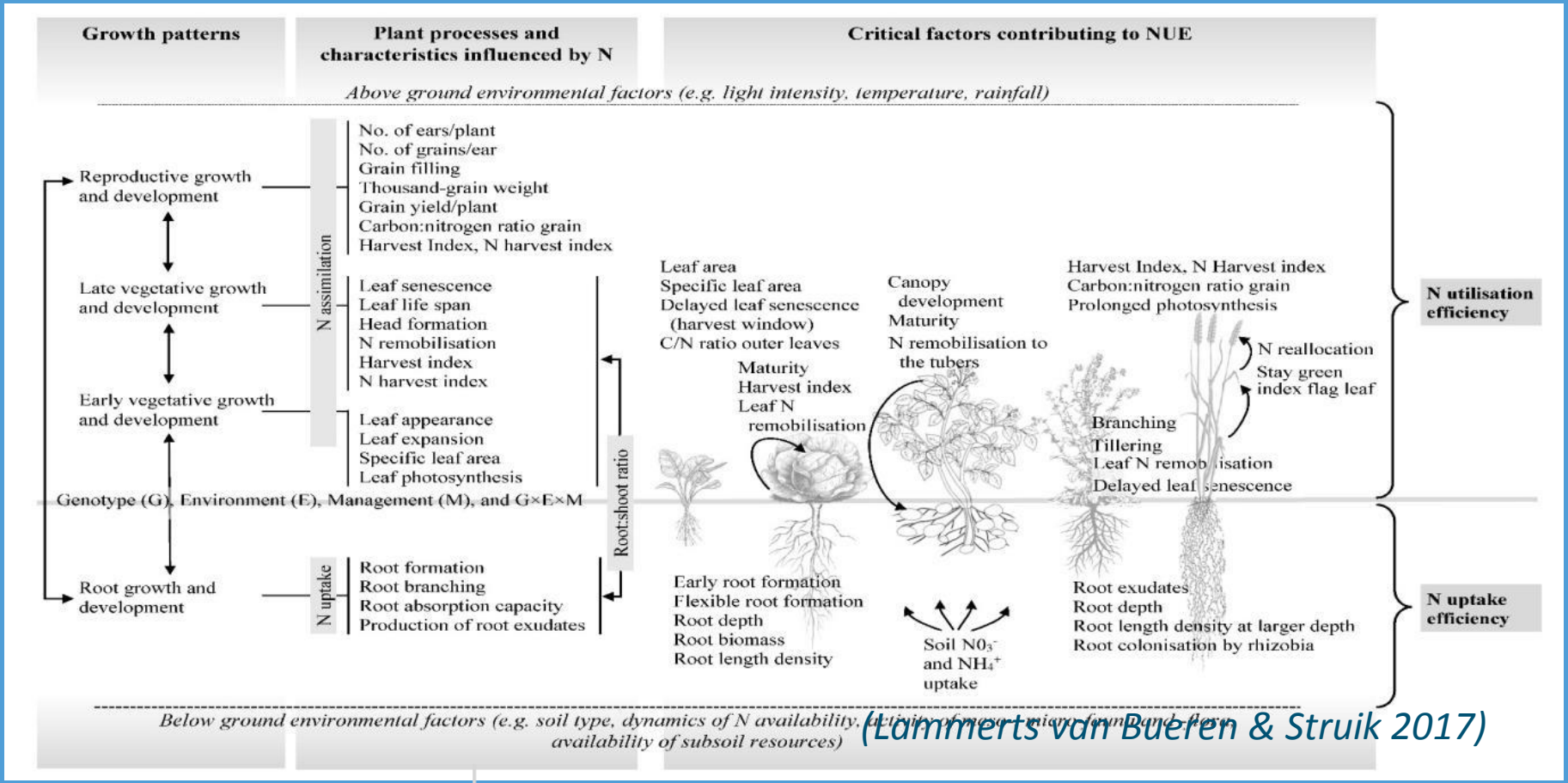
Below-ground traits:
Diverse concepts of breeding for NUE (nutrient uptake and utilisation)

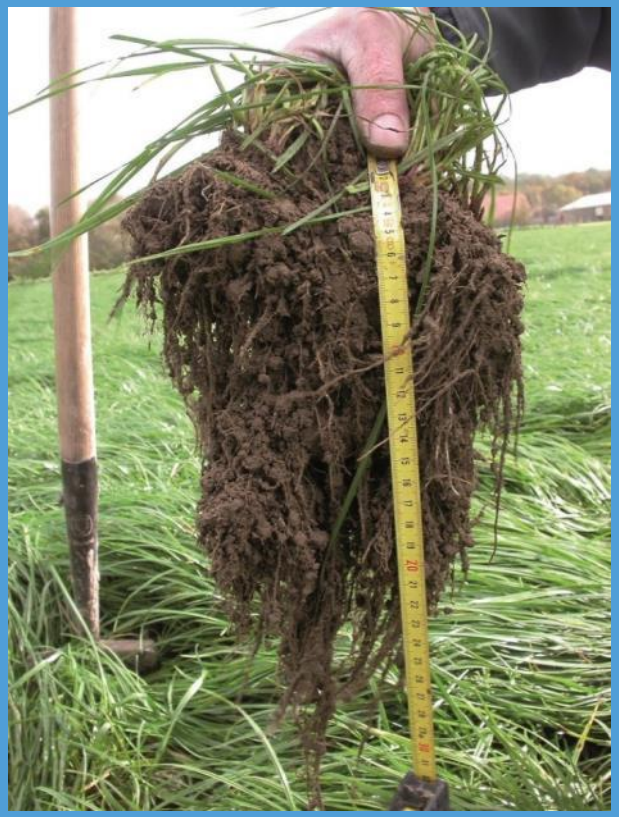


(Lammerts van Bueren & Struik 2017)

Below-ground traits:
Breeding for 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



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

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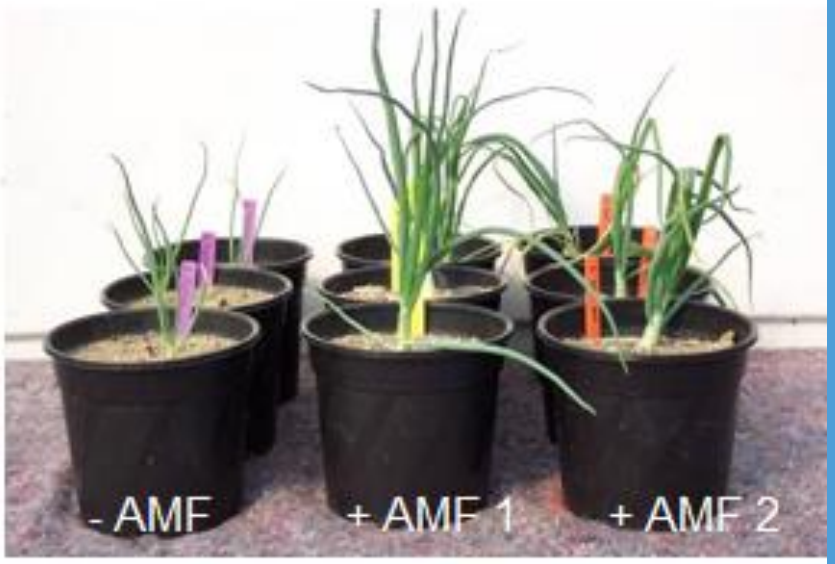
Below-ground traits
Selecting for improved interaction with mycorrhiza's

Adaptation to organic soil fertility management, also requires:

- Varieties capable cooperating with beneficial soil micro-organisms, such as mycorrhiza's (AMF)



(Scholten et al., 2005)

No herbicides: weed pressure

Conventional

Organic

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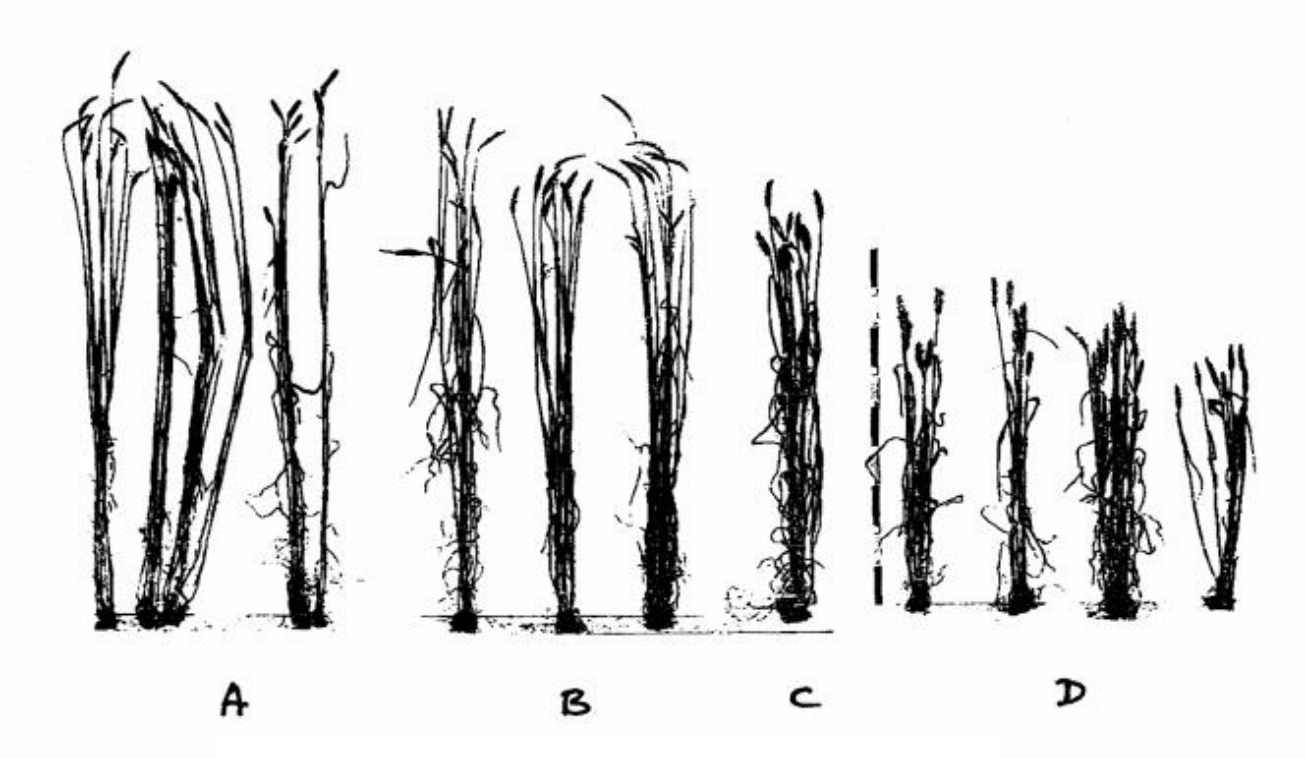
Wheat: erectophile (left) or planophile (right)?

Weed suppressive ability: leaf orientation, leaf width, leaf and plant length

Weed suppressive ability:
At later growth stages: plant (straw) length

- more straw
- more shade for weed competitiveness in later growth stages
- less ear diseases

Changes in wheat varieties from 1900 -1980



A. 5 regional varieties ca.1900
B. 3 varieties of 1950
C. 1 variety of 1965
D. 4 varieties of 1980

Wheat with clover undersown: erect types

Weed suppressive ability?

But sometimes erect types are required…

Leek and onion need erect plant types

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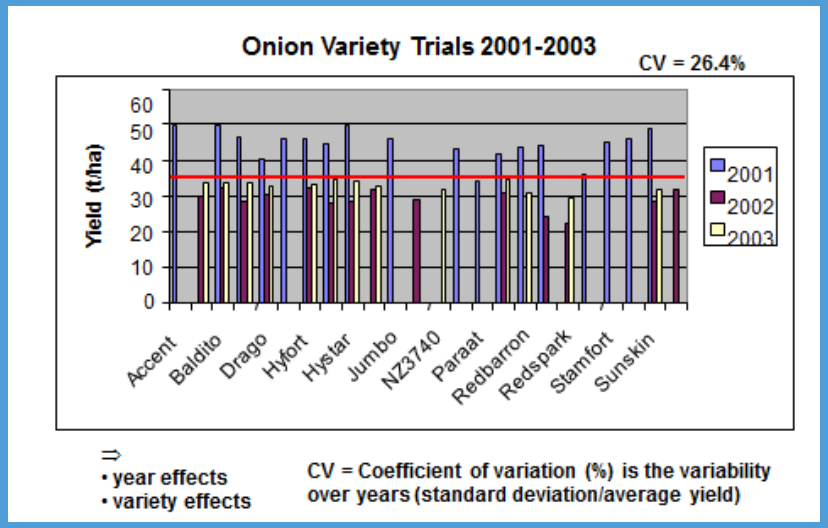
Traits included in organic ideotype scores for barley (Latvia)

Traits	Growing stage (GS) according to Zadoks et al. (1974)	Relative weight (%) in the Organic Ideotype Score
Grain yield	After harvest	40
Traits contributing to competitive ability against weeds		
Canopy height at stem elongation stage	GS 31-32	20
Crop ground cover	GS 31-32	10
Width of flag leaves	GS 47 – 51	2
Length of flag leaves	GS 47 – 51	2
Lodging resistance	GS 90	2
Plant height at maturity	GS 90	6
Traits related to growing period		
Thermal time to heading	GS 51	5
Thermal time to maturity	GS 90	5
Disease resistance		
Resistance to leaf diseases (powdery mildew and net blotch)	From GS 32 onwards	6
Traits related to grain quality		
Volume weight	After harvest	2
		Total 100

(Kokare et al. 2017)

Traits for reduced susceptiblity to pest and diseases

Downy mildew resistance urgently needed
in onion production

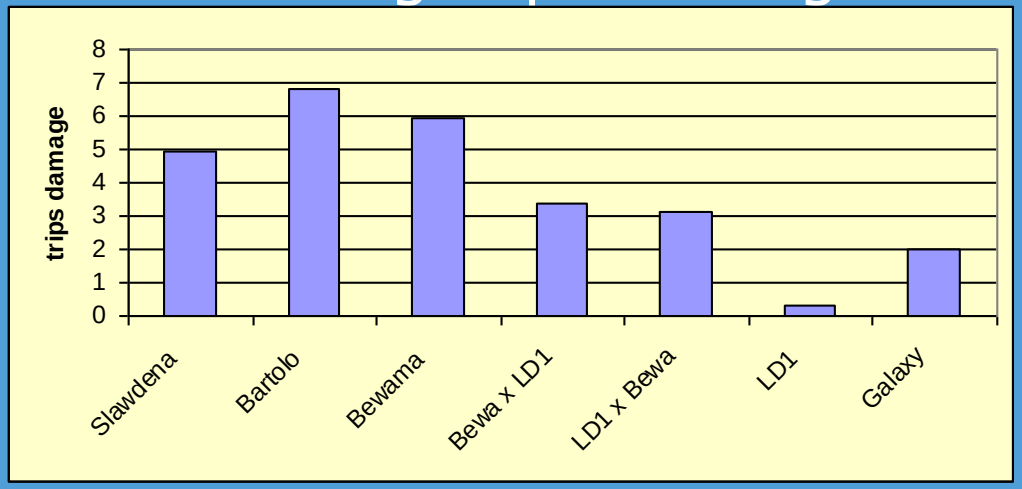


(Lelystad, 2002)

Required traits for reduced susceptiblity to pest and diseases

Or additional morphological and physiological plant characteristics that can support reduced susceptibility,

- such as wax layer on leaves reducing trips damage

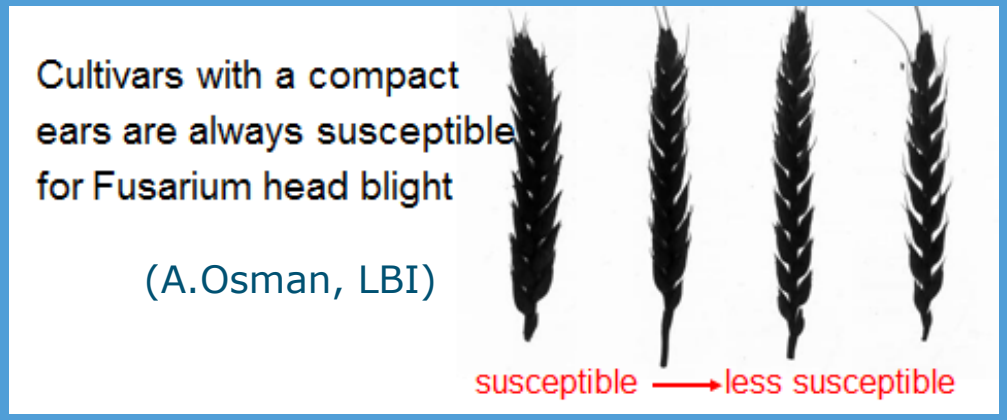


(*Voorrips et al. 2008*)

Required traits for reduced susceptiblity to pest and diseases

Or additional morphological and physiological plant characteristics that can support reduced susceptibility,

- such as wax layer on leaves
- less compact ear (cereals)



Required traits for reduced susceptiblity to pest and diseases

Or additional morphological and physiological plant characteristics that can support reduced susceptibility,

- such as wax layer on leaves
- less compact ear (cereals)
- better root system
  (continuous growth)
- early maturing (escape)

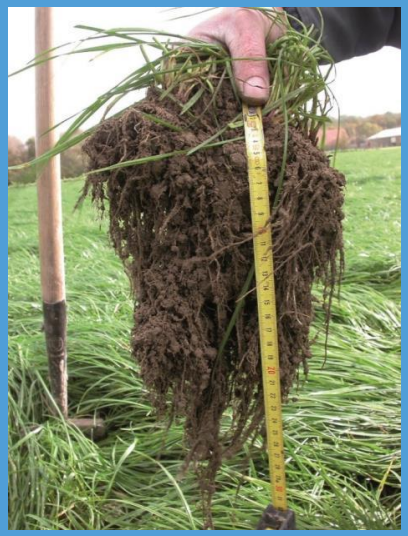


Table 2. Comparison of the approved organic and conventional protocols for VCU testing for spring wheat. (Lammerts van Bueren et al., 2001).

	Organic Protocol	Conventional Protocol
Research site	Managed organically, in accordance with EU regulation 2092/91, for at least three years	• Managed conventionally with mineral fertilisers; chemical pest and disease control
Seed	• Not chemically treated	• Chemically treated
Crop husbandry	• According to organic farm management practice	• according to conventional management practice; part of the trial is conducted without chemical protectants
Plant characteristics, which are not observed in conventional spring wheat VCU *	• recovery from mechanical harrowing	• not observed
	• tillering	• not observed
	• speed of closing the crop canopy	• not observed
	• canopy density	• not observed
	• stay green index	• not observed
	• distance of ear-flag leaf	• not observed
	• compactness of the ear	• not observed
	• resistance against sprouting	• not observed
	• black molds in the ear	• not observed
Evaluation baking quality	• evaluation on whole wheat bread without artificial bread improvers	• evaluation on white bread with addition of ascorbic acid

* Other aspects that are observed and listed in the conventional protocol as well as in the organic protocol are not mentioned.

Exploiting genetic diversity e.g. 'heterogeneous material'

Composite cross populations:
►Multiple crosses

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

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Exploiting genetic diversity

- 1. Grow many varieties –
  not always practical, little interaction
- 2. Grow variety mixtures –
  good for in-field interactions;
  no new genetic variation
- 3. Grow segregating populations –
  evolutionary breeding, inter crossing
  continuously renewing genetic diversity

Why populations? Resilience driven!

An assembly of genetically different individuals offers:

- Capacity: more characters than a pure stand
- Complementation: different genotypes may complement each other
- Compensation: if some fail, others take their place
- Competition: this is the major factor that may work against the three 'Cs' above, particularly with limited resources.

Composite crosses in UK (2000 onwards): selecting of parent lines (at least 5 or more…)

High Yield Potential

1 Bezostaya
2 Buchan
3 Claire
4 Deben
5 High Tiller Line
6 Norman
7 Option
8 Tanker
9 Wembley

Plus 4 male sterile lines

High Quality Potential

1 Bezostaya
2 Cadenza
3 Hereward
4 Maris Widgeon
5 Mercia
6 Monopol
7 Pastiche
8 Renan
9 Renesansa
10 Soissons
11 Spark
12 Thatcher

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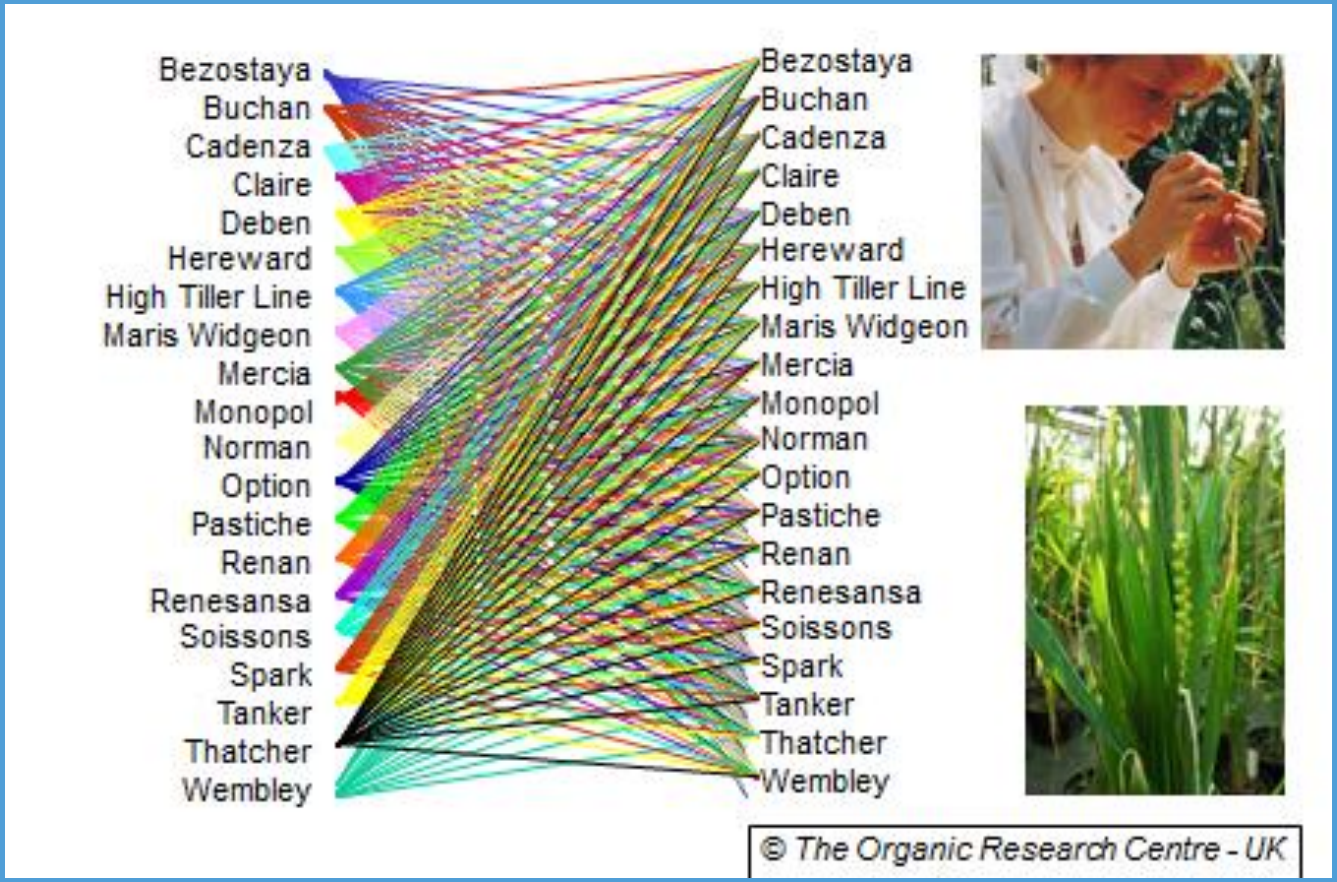
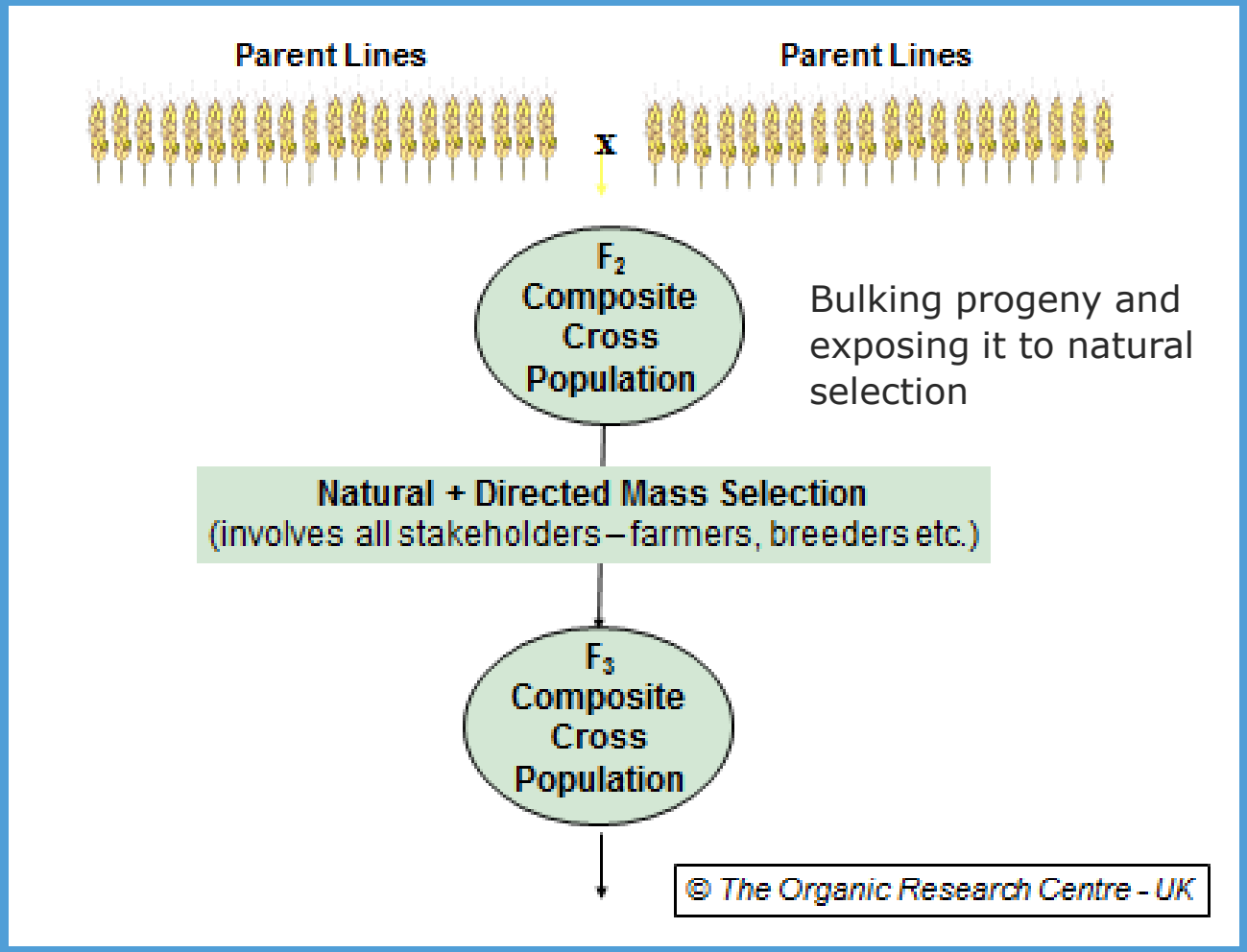
Production of 190 cross combinations (ORC and John Innes Institute, UK)



Composite cross breeding process



EU experiment in NL (wheat, 2014-2017)

Draft report of Edwin Nuijten/LBI and Ad Toussaint/NAK:

- For buyers important to know what is
  - Breeding method (parents, breeding scheme)
  - Production method (history, growing conditions, region, …)
- CCPs can be distinguished by morphological and quality traits (e.g. baking quality, disease resistance, plant length, etc)
- Some populations are more stable than others, depending on year and location
- Normal rules should apply for seed quality

Heterogenous material

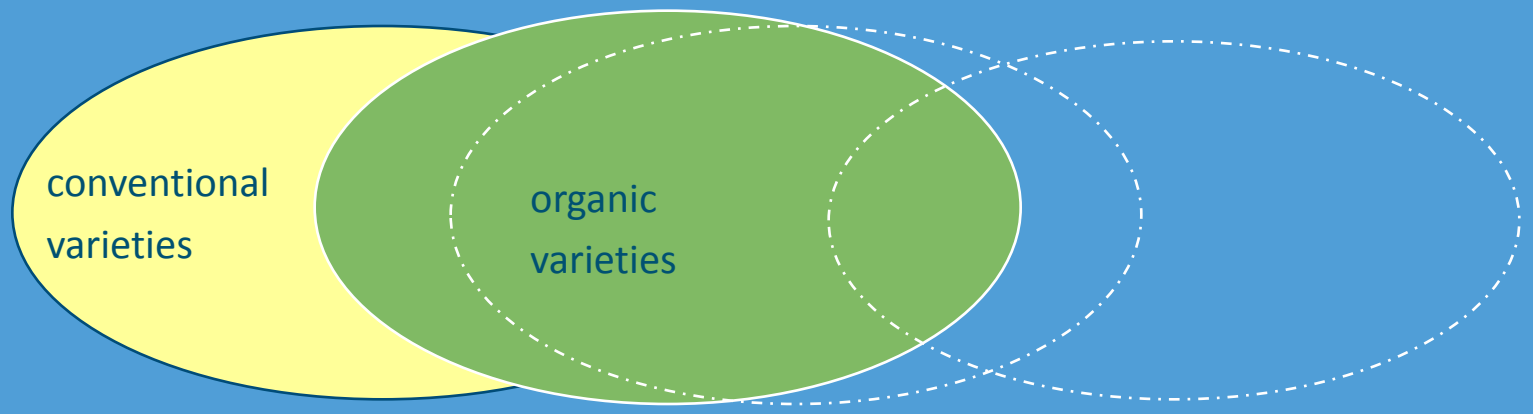
Observations EU LIVESEED project until now:

- What heterogeneous material will bring is a learning process,
- that requires time to find out pro's and contra's that might differ per crop species;
- Development of heterogeneous material will be different per crop species, depending on crop characteristics during growth and multiplication, market demands and type of value chain or food system.
- Note: heterogeneous material is an addition to organic variety concept, not a replacement!

Overlap between conventional and organic varieties

The degree of overlap between conventional and organic suited varieties depends on:

- the crop requirements
- the growing conditions (high or low input)
- applied breeding techniques or strategies



Thank you so much!

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