Organic breeding principles and applications

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Edith Lammerts van Bueren

edith.lammertsvanbueren@wur.nl

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Organic agriculture: 4 Basic Principles

Organic agriculture is often known as:

- No chem-synthetic fertilisers, pesticides, fungicides and herbicides, and no GMOs
- But organic is better defined by the 4 basic principles:

www.ifoam.bio

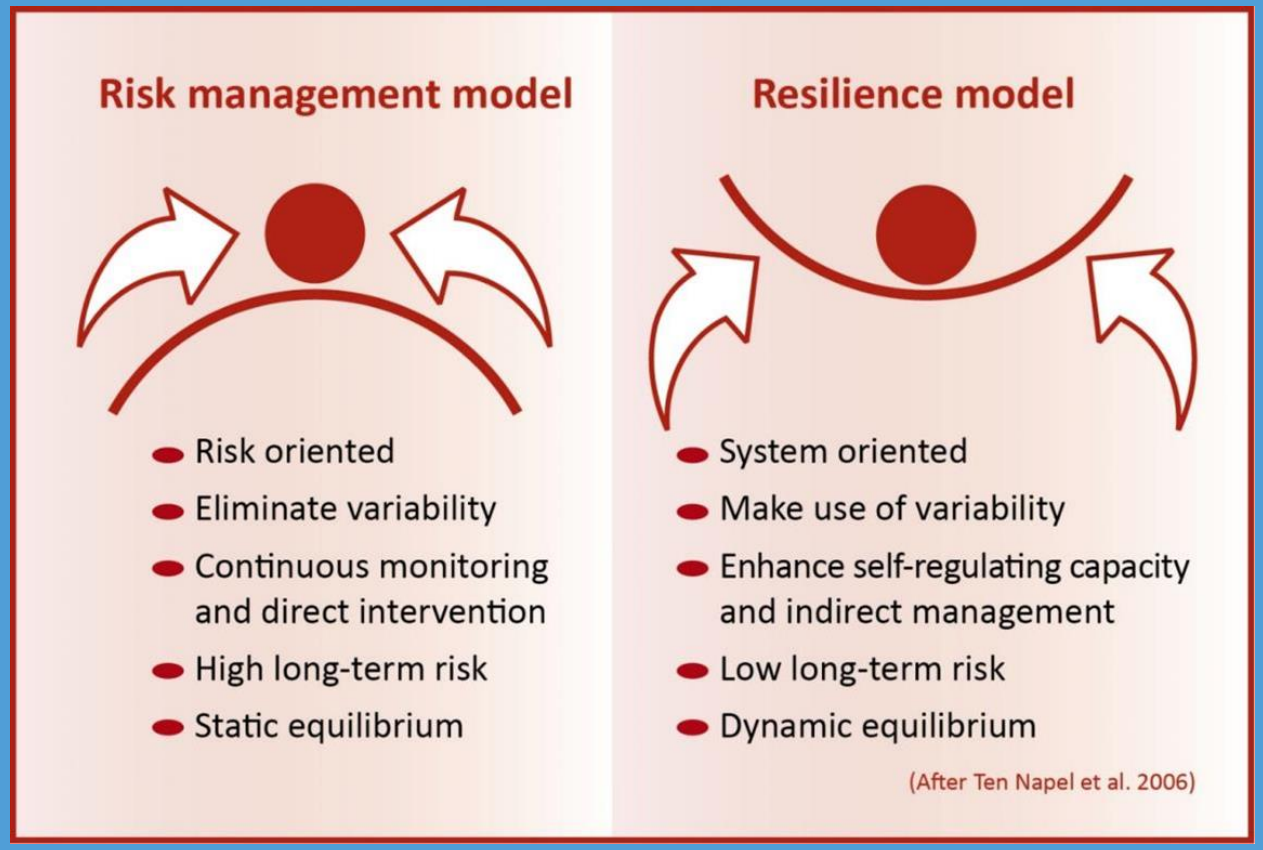
1. Principle of Health

Principle of Health in organic plant breeding:

• serving the wholeness and integrity of living systems (immunity, resilience, regeneration, sustainability):

- robust and dynamic/flexible varieties
- weed suppressive and disease tolerant
- varieties that can benefit from interactions with beneficial soil organisms
- and that are able to produce seed under organic management.

!. Principle of health



Varieties that allow the organic system to work!

2. Principle of Ecology

Principle of Ecology in organic plant breeding:
• contribute to optimally functioning of a diversity of site specific ecological production systems:

- breeding for regional adaptability
- regional, decentralized breeding
- enhancing genetic diversity
- making use of ecological principles:

  e.g. by not only focusing on genetic resistances, but on a multi level approach and also include morphological and physiological characteristics.

3. Principle of Fairness

Principle of Fairness in organic plant breeding,

- serving equity, respect, justice and stewardship of the shared world:

  - free access to genetic resources
  - no patents on life
  - participatory breeding approaches
  - equal benefit sharing

4. Principle of Care

The principle of Care in organic plant breeding:

- enhance efficiency and productivity in a precautionary and responsible manner,

  - refrain from NBTs and related techniques
  - no cell fusion

Summary of goals for organic breeding

Principle of health
Develop varieties respecting plant integrity as part of the whole agricultural-ecosystem

Principle of ecology
Develop multi-level breeding approaches

Principle of fairness
Develop new socio-economic structures

Principle of care
Within the organic framework there is plenty of unexplored (and forgotten) knowledge for new multi-faceted breeding strategies!

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

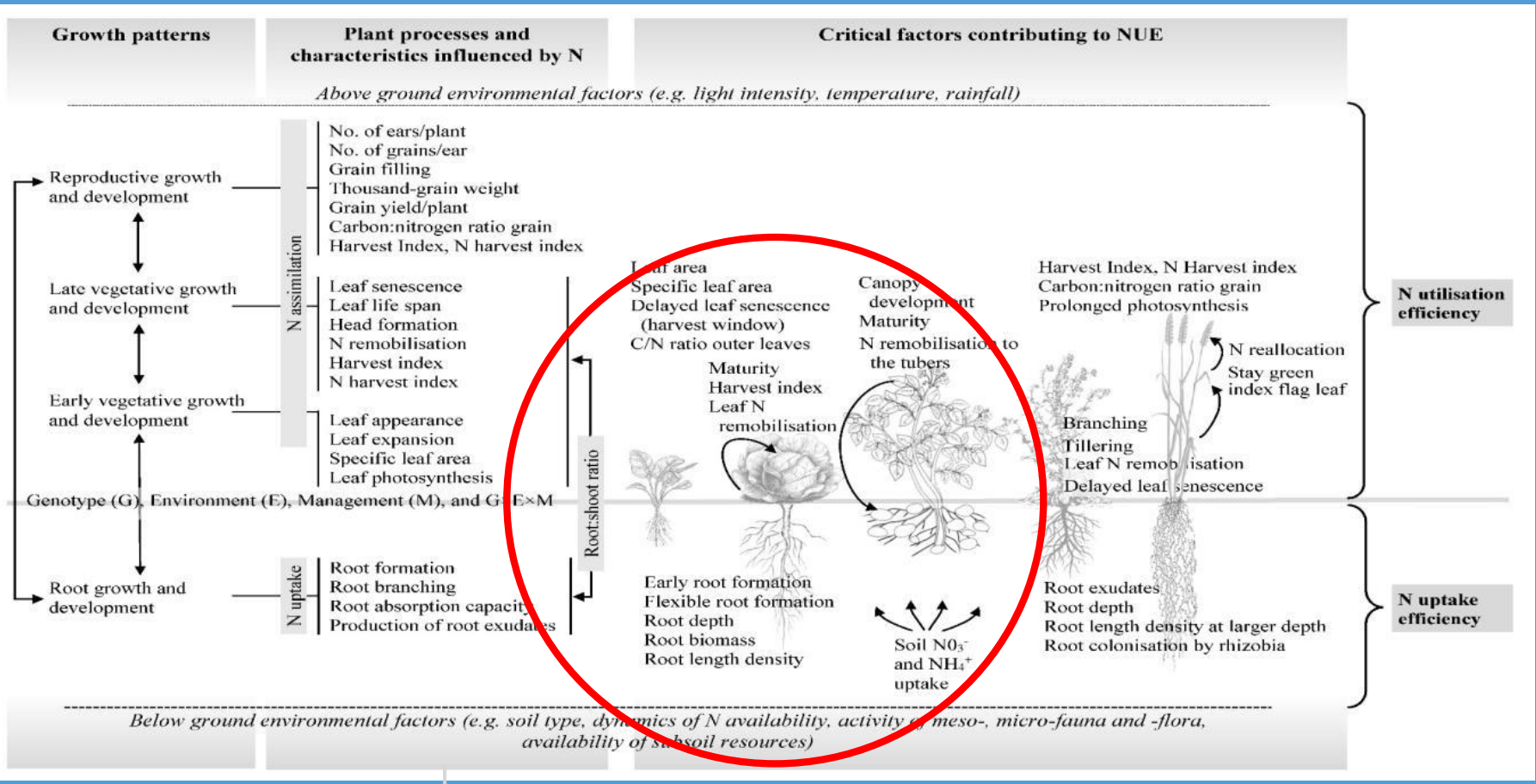
Nitrogen use efficiency (NUE) in cabbage

- Breeders can contribute by improving the nitrogen use efficiency (NUE) within a crop species, i.e. by increasing the harvest produced per unit N supplied.

150 kg N/ha (left)

300 kg N/ha (right)

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



(Lammerts van Bueren & Struik 2017)

Below-ground traits:
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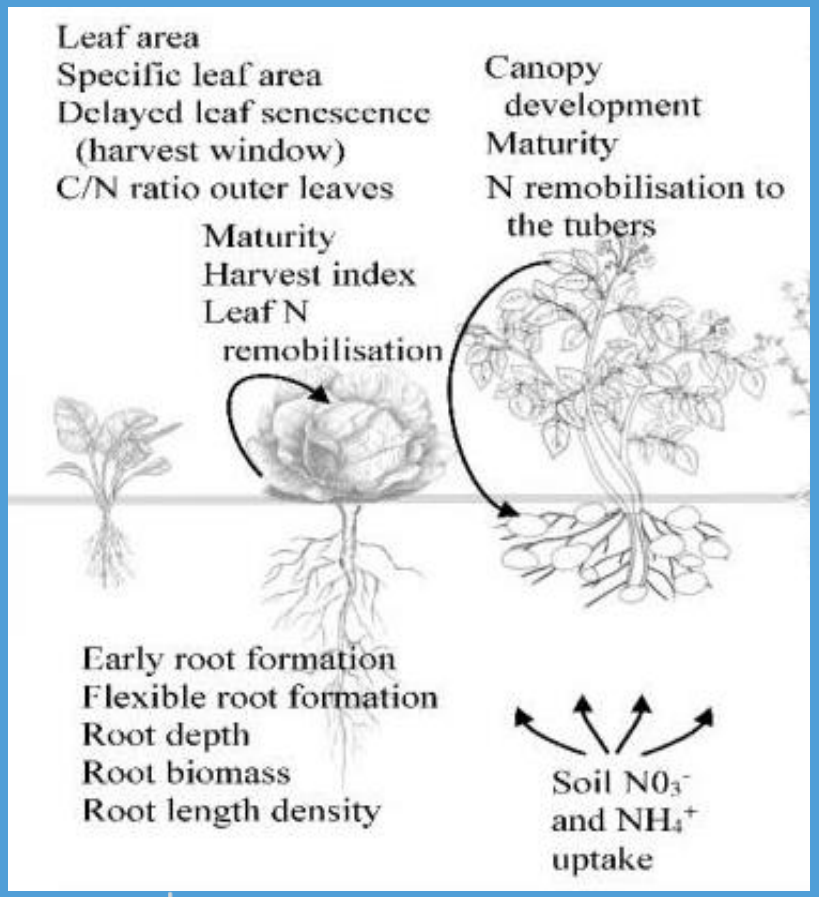
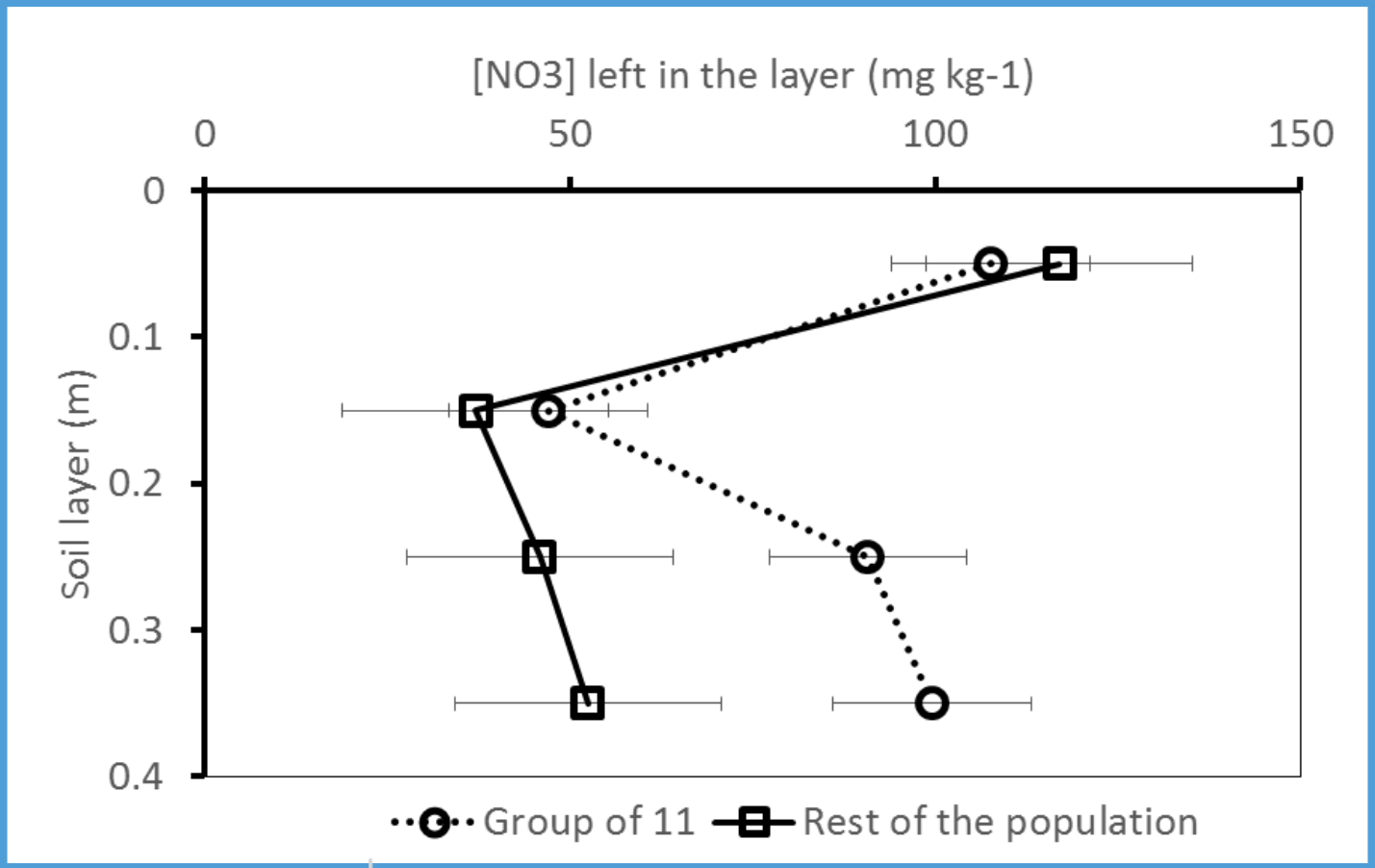


(Lammerts van Bueren & Struik 2017, in Agronomy for Sustainable Development)

QTL analysis identified genetic differences in lettuce for nitrate capture in different soil layers



Significant genotypic-phenotypic associations found on the 4th chromosome (Distances in cM) of lettuce (4 trials, 150 genotypes)

	Wageningen				Voorst			
Trial #	1		2		1		2	
Conditions	Dry & Cool		Moist & Warm		Dry & Cold		Humid & Cool	
Sampling #	Inter	Final	Inter	Final	Inter	Final	Inter	Final
All NO3 in profile		32				**~ 80** 135		**~80**
[NO3] in L1								
[NO3] in L2			**42-46** 69					146
[NO3] in L3				**~ 80**				**~ 80**
[NO3] in L4				**42**				**~ 80**

QTL potentially involved in Nitrate capture were previously associated with root elongation by Johnson et al. (2000) in a wild x cultivated cross

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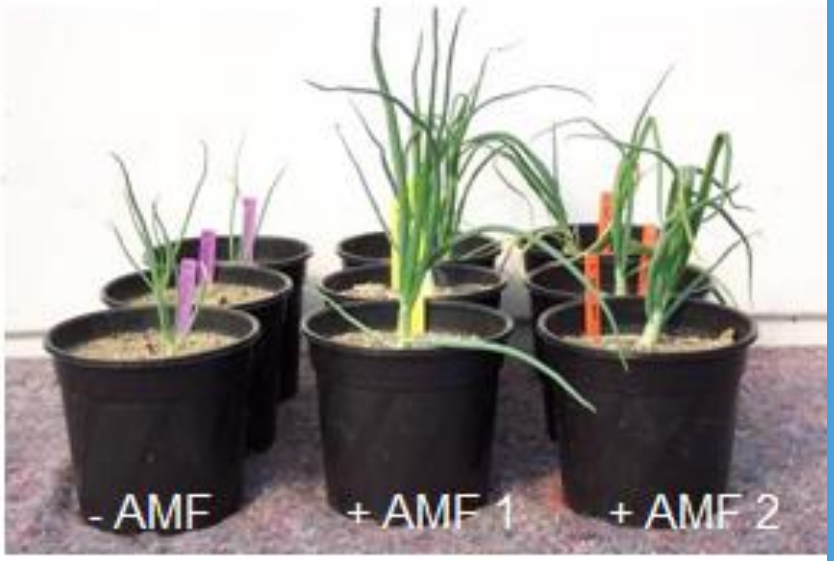
Kerbiriou et al., 2016, Frontiers in Plant Science

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)

Weed suppressive ability

Erect growth types, allowing more light on the soil

Planophile, soil covering growth types

Weed suppressive ability:
But sometimes erect types are required...

Leek and onion need erect plant types

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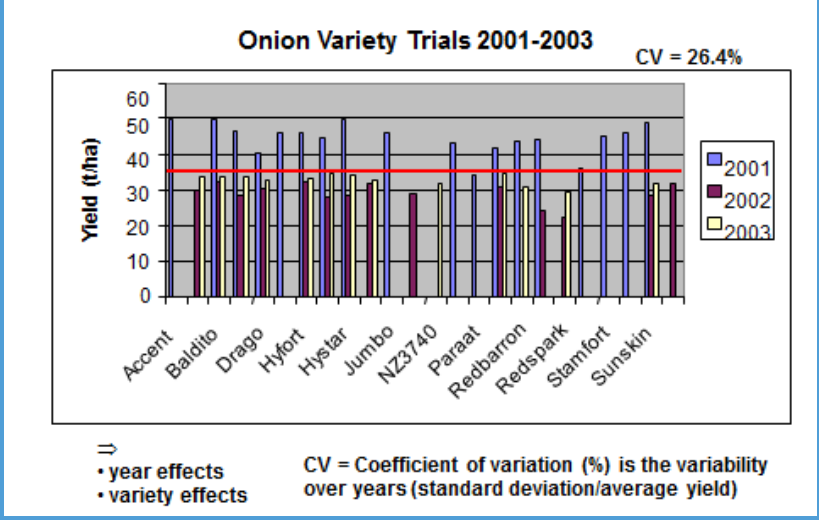
Traits for reduced susceptiblity to pest and diseases

Downy mildew resistance urgently needed in onion production

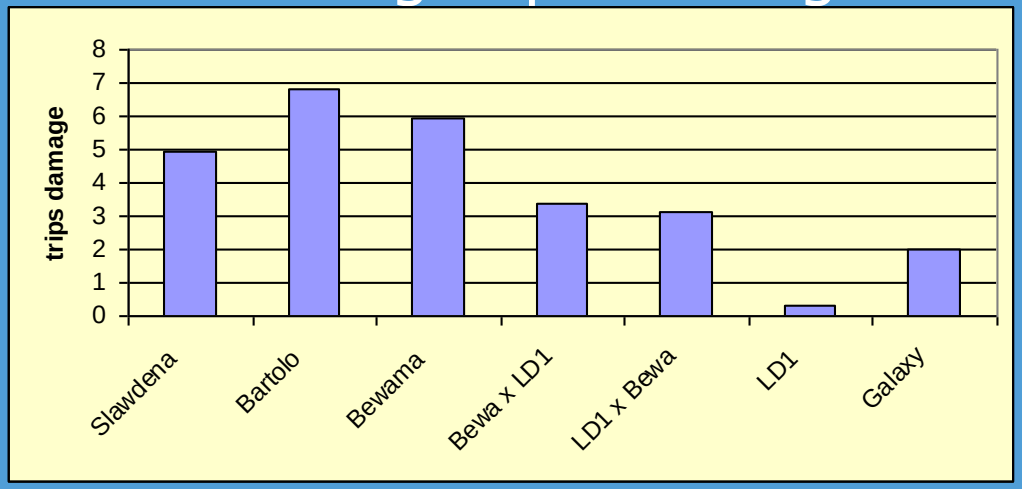


(Lelystad, 2002)

Required traits for reduced susceptiblity to pest and diseases

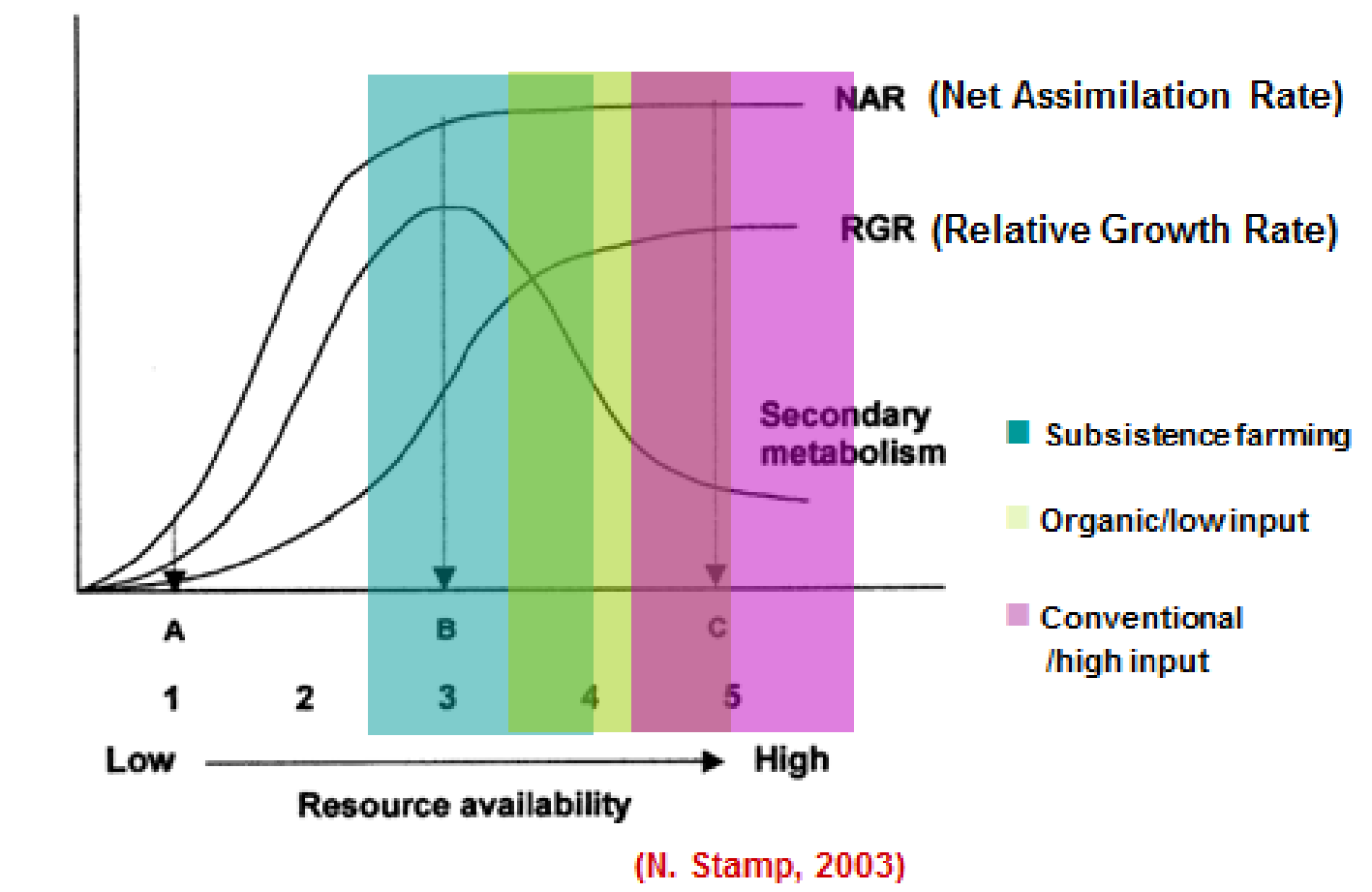
Or additional morphological and physiological plant characteristics that can support reduced susceptibility,

- such as wax layer on leaves reducing trips damage

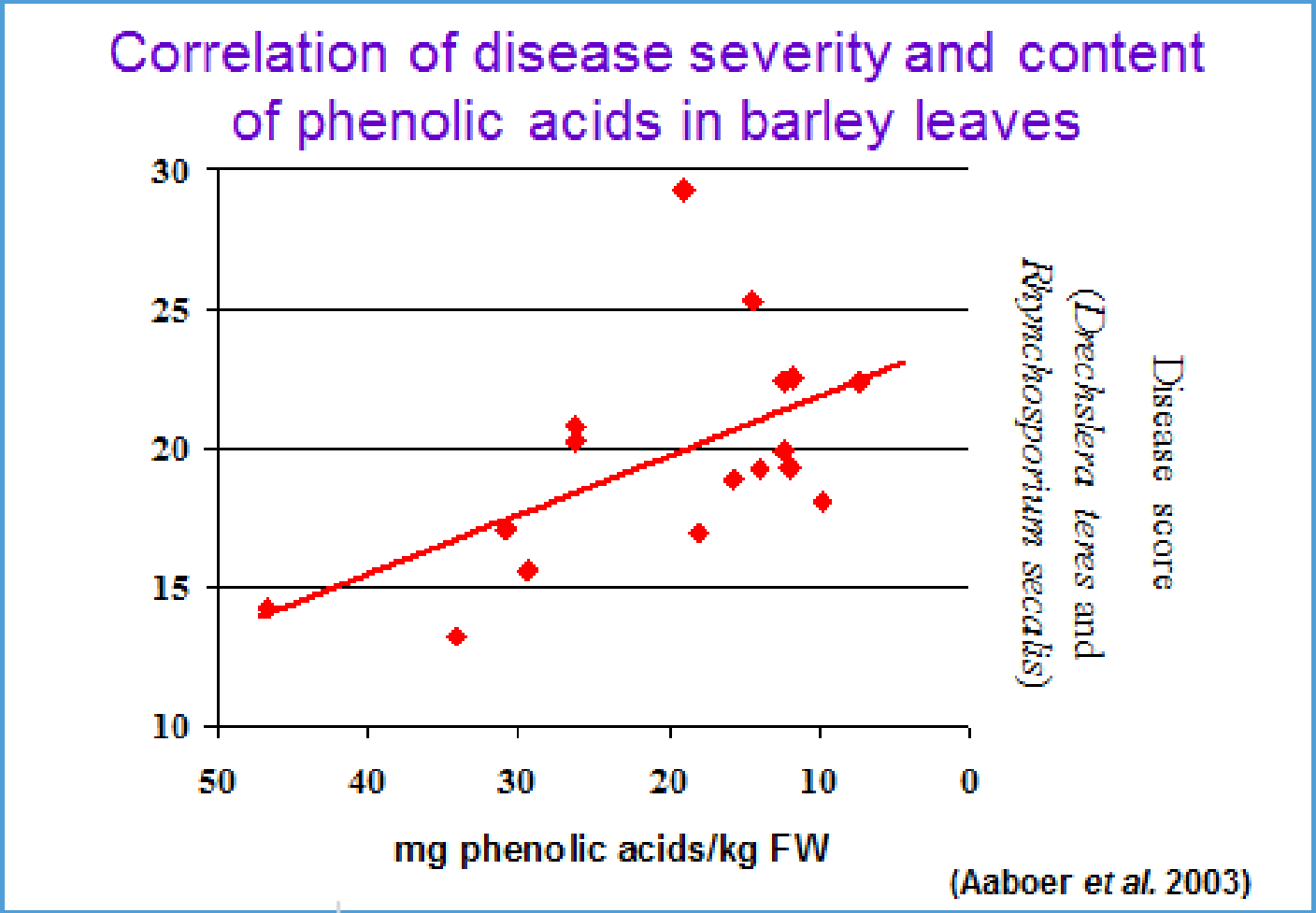


(*Voorrips et al. 2008*)

Secundary metabolites
Physiological response to nutrient availability



Innovative ways of enhancing plant defense mechanisms



Changes in ranking between conv and organic, in spring vs autumn broccoli

Table 7a Ranking of Average head weight (g) of 23 cultivars grown under organic (O) and conventional (C) conditions in Maine in two seasons (Fall and Spring) from 2006-2008 (Top 5 ranking per production system and rank performance in inverse system).

Maine												
Fall 2006-2007							Spring 2007-2008					
C				O			C			O		
1	Packman	369.12		431.55	Green Magic*	1	1	Marathon	243.23	251.22	Fiesta	1
2	Fiesta	365.84		424.54	Packman	2	2	Nutribud	243.03	251.01	Green Magic	2
3	Everest	360.63		400.85	Fiesta	3	3	Imperial	240.58	247.13	Imperial	3
4	Green Goliath	353.19		398.64	Everest	4	4	Early Green	240.03	240.54	B1 10	4
5	Belstar	346.40		397.69	Green Goliath	5	5	Batavia	232.21	228.09	Belstar	5
6	Batavia	344.06		392.90	Batavia	6	6	Belstar	226.65	221.99	Batavia	6
7	Diplomat	335.92		368.41	Belstar	7	7	Fiesta	224.16	217.02	Arcadia	7
8	Patriot	334.62		367.69	B1 10	8	8	Green Magic	219.09	212.09	Gypsy	8
9	B1 10	324.87		361.73	Marathon	9	9	B1 10	218.66	207.44	Green Goliath	9
10	Green Magic	324.51		352.87	Maximo	10	10	Maximo	214.99	205.29	Maximo	10
11	Nutribud	316.64		352.80	Patron	11	11	Premium Crop	211.52	204.94	Marathon	11
12	Patron	309.19		333.61	Patriot	12	12	OSU OP	202.65	202.50	Nutribud	12
13	Marathon	302.10		332.76	Early Green	13	13	Patriot	200.32	201.68	Patriot	13
14	Maximo	291.91		324.92	Premium Crop	14	14	Green Goliath	199.09	195.29	OSU OP	14
15	Gypsy	272.64		322.01	Gypsy	15	15	Packman	190.28	191.08	Premium Crop	15
16	Premium Crop	270.82		317.56	Imperial	16	16	Beaumont	189.06	185.53	Beaumont	16
17	Early Green	264.77		307.54	Arcadia	17	17	Diplomat	187.54	180.03	Diplomat	17
18	Imperial	253.36		298.50	Nutribud	18	18	Everest	182.25	167.44	Early Green	18
19	Arcadia	252.42		288.51	Diplomat	19	19	Arcadia	180.48	167.12	Packman	19
20	USVL 093	232.22		265.48	USVL 048	20	20	Gypsy	177.61	166.27	Patron	20
21	OSU OP	211.72		258.03	Beaumont	21	21	Patron	163.93	156.96	Everest	21
22	USVL 048	200.30		219.26	USVL 093	22	22	USVL 093	156.48	146.78	USVL 048	22
23	Beaumont	110.74		218.28	OSU OP	23	23	USVL 048	138.98	103.29	USVL 093	23

(Renaud et al. 2014, Crop Science)

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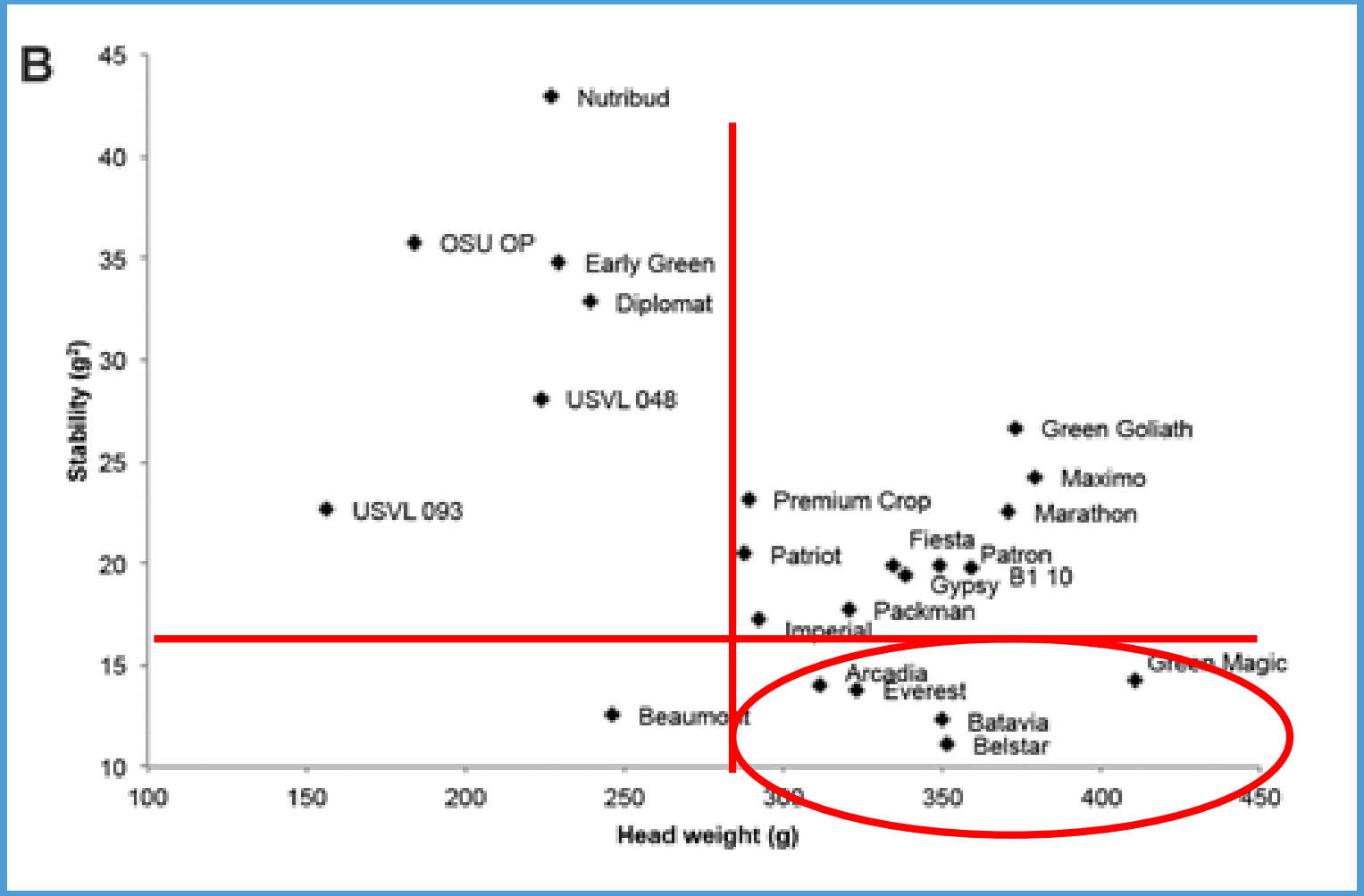
Yield stability ranking versus head weight of broccoli under organic conditions

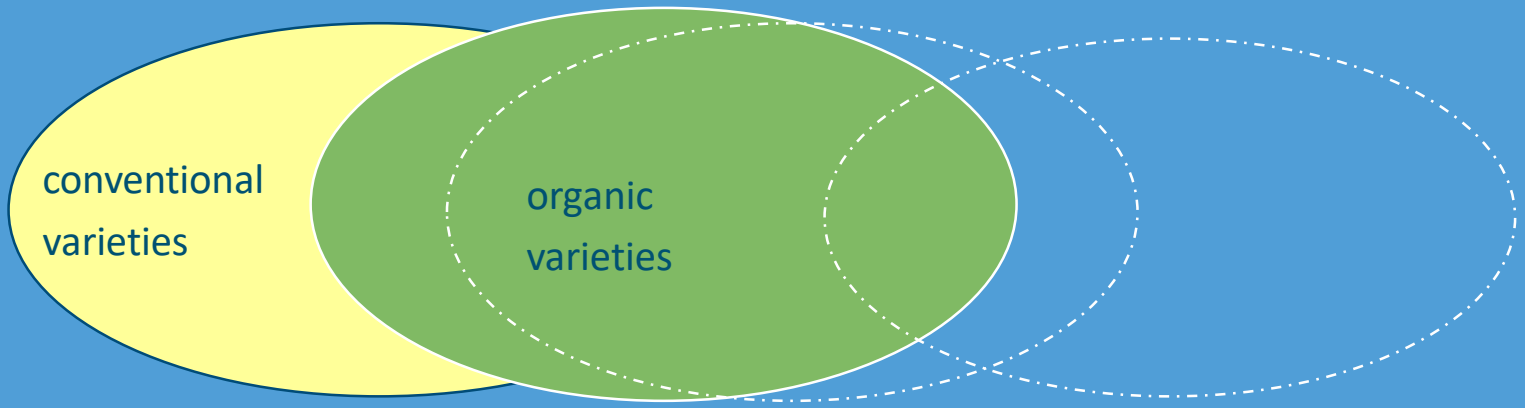


Renaud et al., 2014, Crop Science

Overlap between conventional and organic varieties

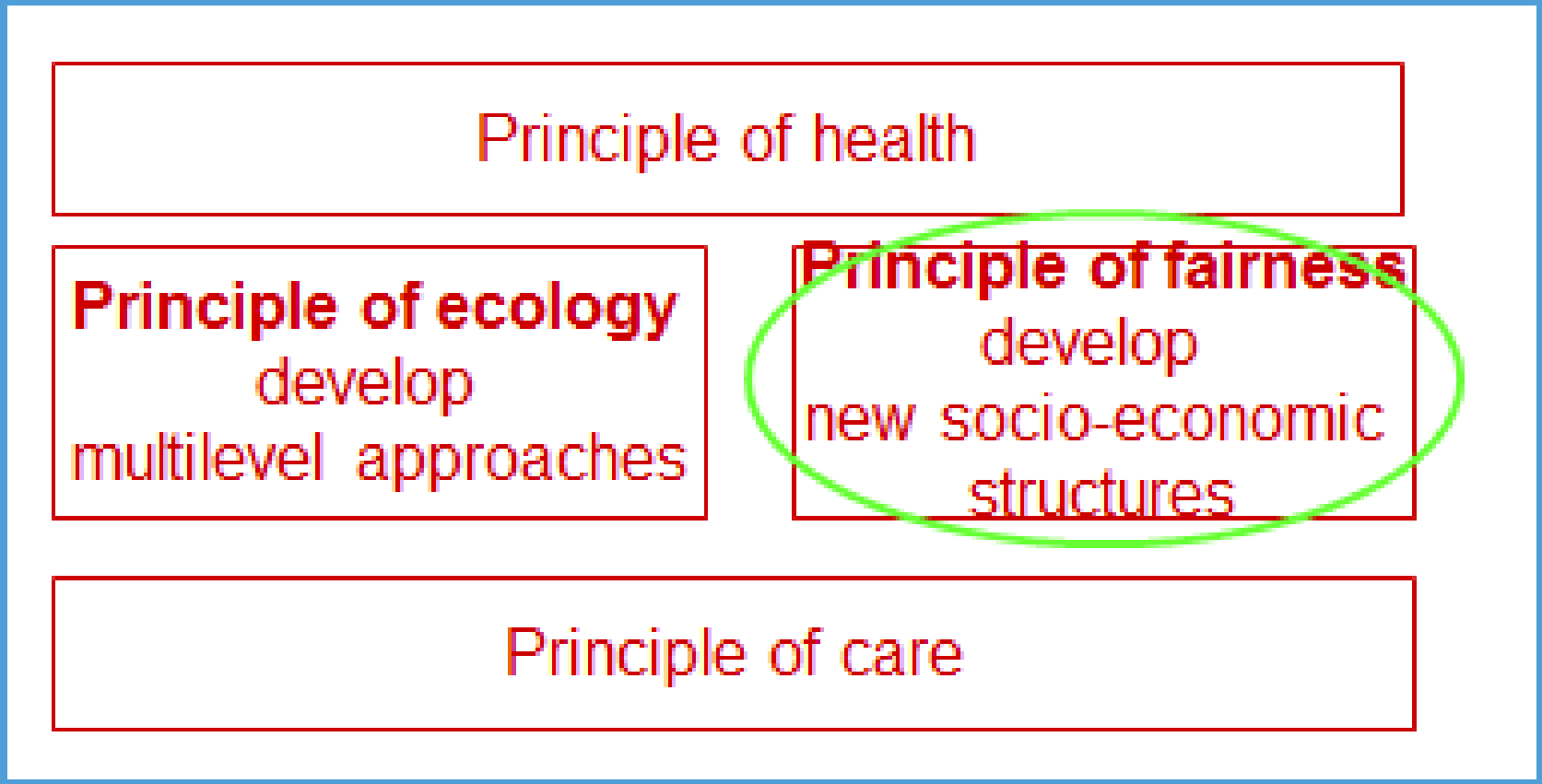
The degree of overlap between conventional and organic suited varieties depends on:

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



Future challenge: plant breeding for ecological and societal resilience!

(Lammerts van Bueren et al. 2018)



Recent development in the Netherlands

De Beersche Hoeve demeter

Biodynamic Seed & Vegetable Farm De Beersche Hoeve,

100% daughter of
Food Cooperative Odin (25 organic food stores)

Odin

New collaborative models including the value chain

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

Who owns the seed (company)?

Johnny's Selected Seeds

100% employee owned!

References

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Thank you so much!