



Design of Farming Systems

Transition to Sustainable Agriculture
W. Sukkel



Personal introduction

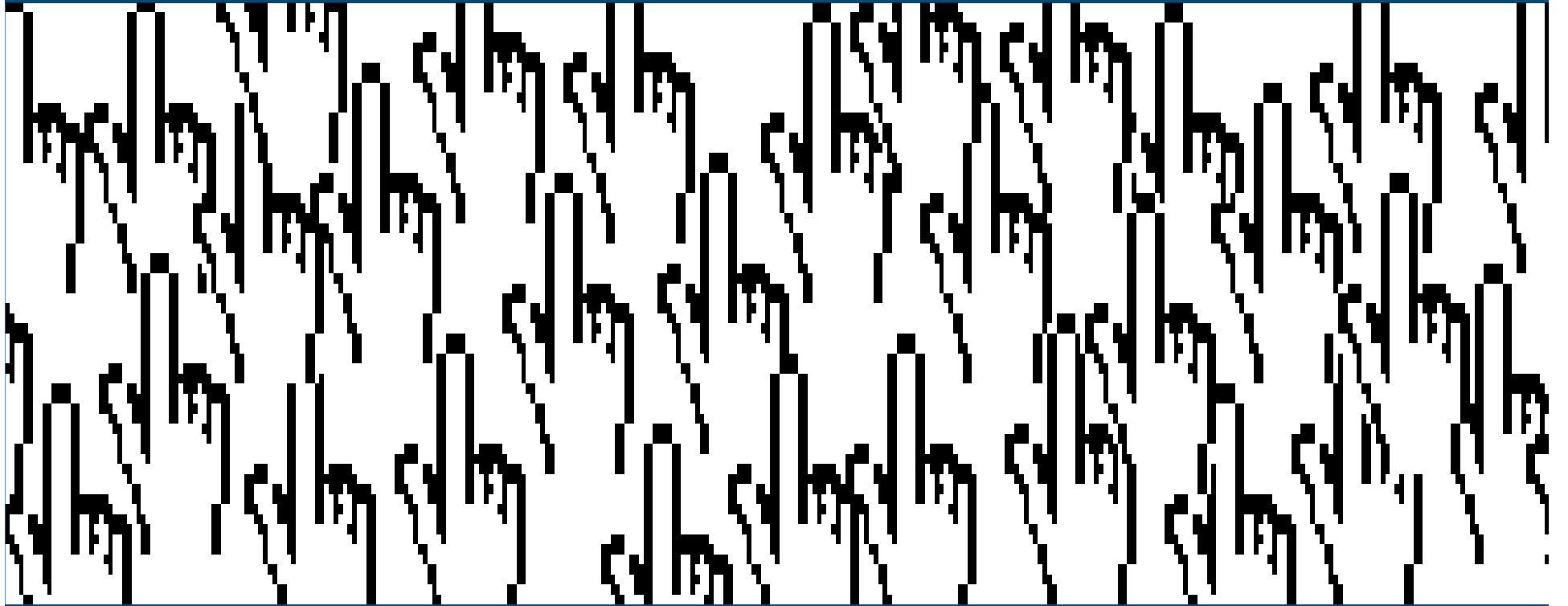
- Wijnand Sukkel
- Agronomist, Specialist farming systems, Organic plant production, Agriculture and Climate Change

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Wageningen University and Research Centre (WUR),



APPLIED PLANT RESEARCH

Questions?





Current Agriculture

What's Wrong?

Whats Right?



APPLIED PLANT RESEARCH



Adverse effects modern agriculture

- Agricultural treadmill
- Pollution
- Depletion, accumulation
- Decrease biodiversity and landscape
- Ending resources
- Climate change (partly caused by agriculture)
-





(Dutch) agricultural problems

Agronomical

- soilfertility and soilhealth
- control of pests diseases and weeds
- high quality demands

Economical

- lower prices, basic income under pressure
- availability and costs of labour



(Dutch) agricultural problems

Environmental/ecological

- pollution of air water and soil with nutrients and pesticides
- decline of nature and landscape

Society

- concern for food safety
- claim for multifunctional land use



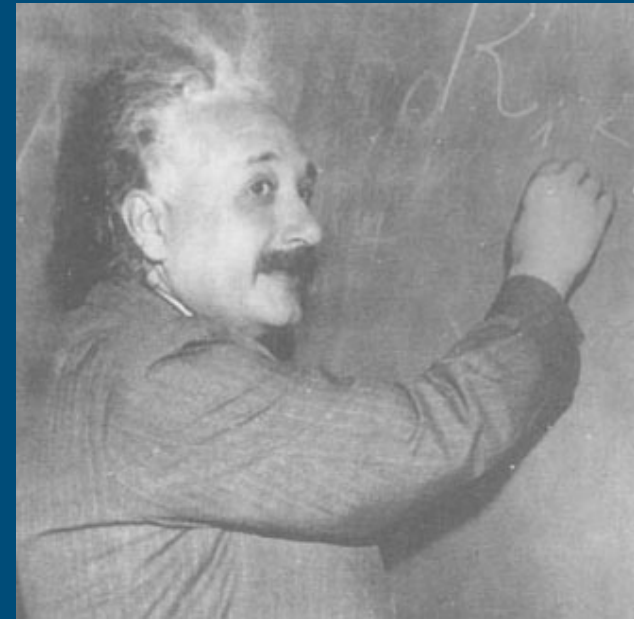
Something has got to change!



But how can we escape from the treadmill??

We cannot solve nowadays problems with the same thinking that created those problems in the past !

(Einstein)





What do we want from agriculture?



Objectives of agriculture

Write down at least 4 general objectives
In order of importance



Multi-objective and Multi-functional Agriculture

- Objectives and functions
 - Food production, Income
 - Clean environment,
 - Biodiversity
 - Maintain/recycle scarce resources
 - CO₂ sequestration
 - Water storage
 - Energy production
 - Recreation, Tourism
 - Silence, darkness
 - Health Care
 -



Conventional	Organic intentional
Uniformity	Diversity
Recipy	Concept
Reductionism	Holism
General	Situational
Control	Cooperation
Specialist	Universalist
Reaction	Precaution
Economy	Ecology
Global	Regional



New coordination mechanisms (1)

- We deal with production, consumption, and everything in between
- Not only productivity, but also ecology, employment, social justice,
- Stakeholders not only farmers but also consumers, transporters, retail, environmental organisations, policy makers, etc.



Conflicts

Ecology



Economy

Diversity



Homogeneity

Need for:

- Farming systems and methods designed to overcome these conflicts
- Social and political solutions



Market demands

- Product uniformity
 - Shape, size, taste, color, quality, price
- High cosmetic quality
- Large volumes
- Supply certainty
- Certified

- Low price



Consequences pressure on costprice

- Mechanisation (crop uniformity)
- Specialisation
- Large Scale
- Capital intensive
- Intensive land use
- Recipy farming



Consequences product demands

- Genetic uniformity
- Phenotype uniformity
- Field and farm uniformity

Which leads to a

- high vulnerability to pests and diseases
- Low tolerance for spots and deformations causing high dependancy of pesticide input
- Non marketable qualities



Agricultural treadmill

- Market demands and low costprice
- Uniformity and high production
- Scale enlargement
- More vulnerability
- Higher protection (sterile conditions)

(free interpretation Cochrane)



Coping with the conflict

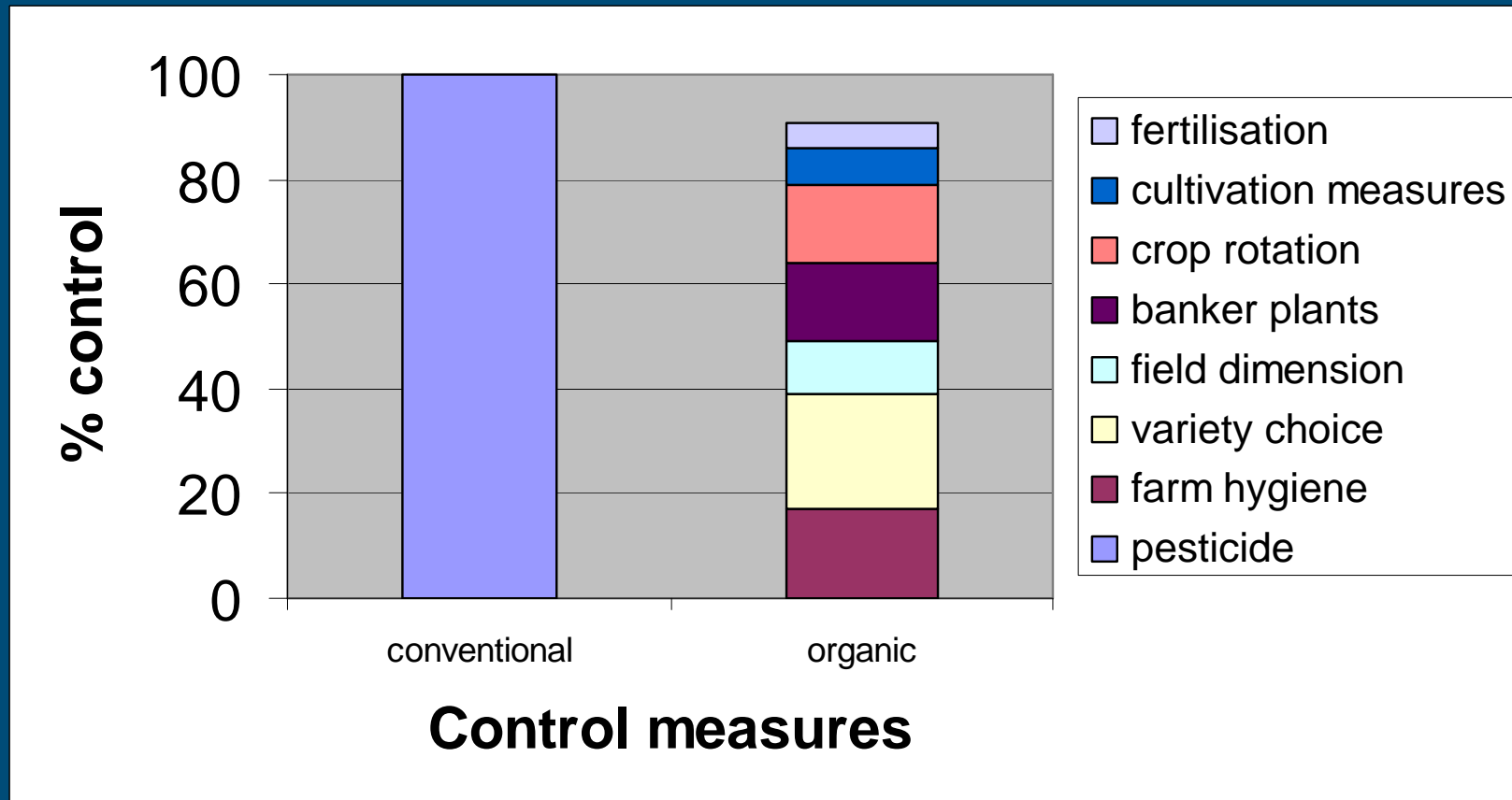
- Social
- Organisational
- Political
- Technical

Escape the 'Agricultural Treadmill'

How to make use of diversity instead of excluding it?



Complex and multi-objective methods



Control pest x (+ landscape + biodiversity + ...)



Agronomic consequences uniformity

Examples

- (inter)National: T plasm maize
- Regional: pest and diseases leek
- Farm or Field level: soil born pests and diseases
- Within plant: vertical resistance



Agronomic demands (organic)

- (Bio)Diversity → stability, resilience, prevention
 - Time
 - Space (plant, field, farm, region)

- Crop rotation
- Farm lay out
 - Dimensions
 - Ecological infrastructure
- Mixed cropping, mixed varieties



APPLIED PLANT RESEARCH



Different approaches

- Socio-political oriented solutions
- Technological solutions
 - **system innovation**
 - process integrated solutions
integrated technology
 - end of pipe solutions
- Participatory innovation or progress



Ingredients for system innovation

- Hardware
- Software
- Orgware



Farming systems research

- System innovation: coherent overall concept, multi-objective
 - Agronomical
 - Ecological
 - Economical

- Integrated technology
 - agro-ecological principles, agronomy and technologyWhole farm



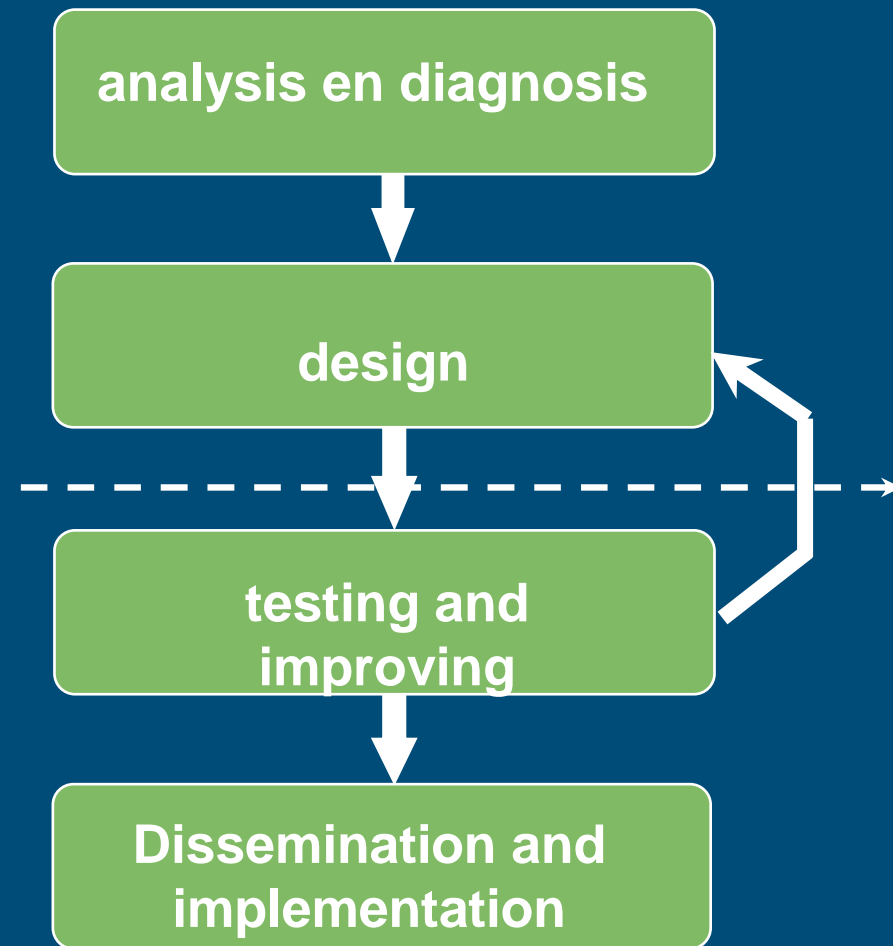
Main search directions

- Conventional agriculture
 - Food production, income
- Integrated agriculture
 - Food production, income, environment, ending resources
- Conservation agriculture
 - Food production, income, environment, ending resources
- Organic agriculture
 - Food production, income, environment, ending resources, biodiversity, social justice, integrity, multifunctional



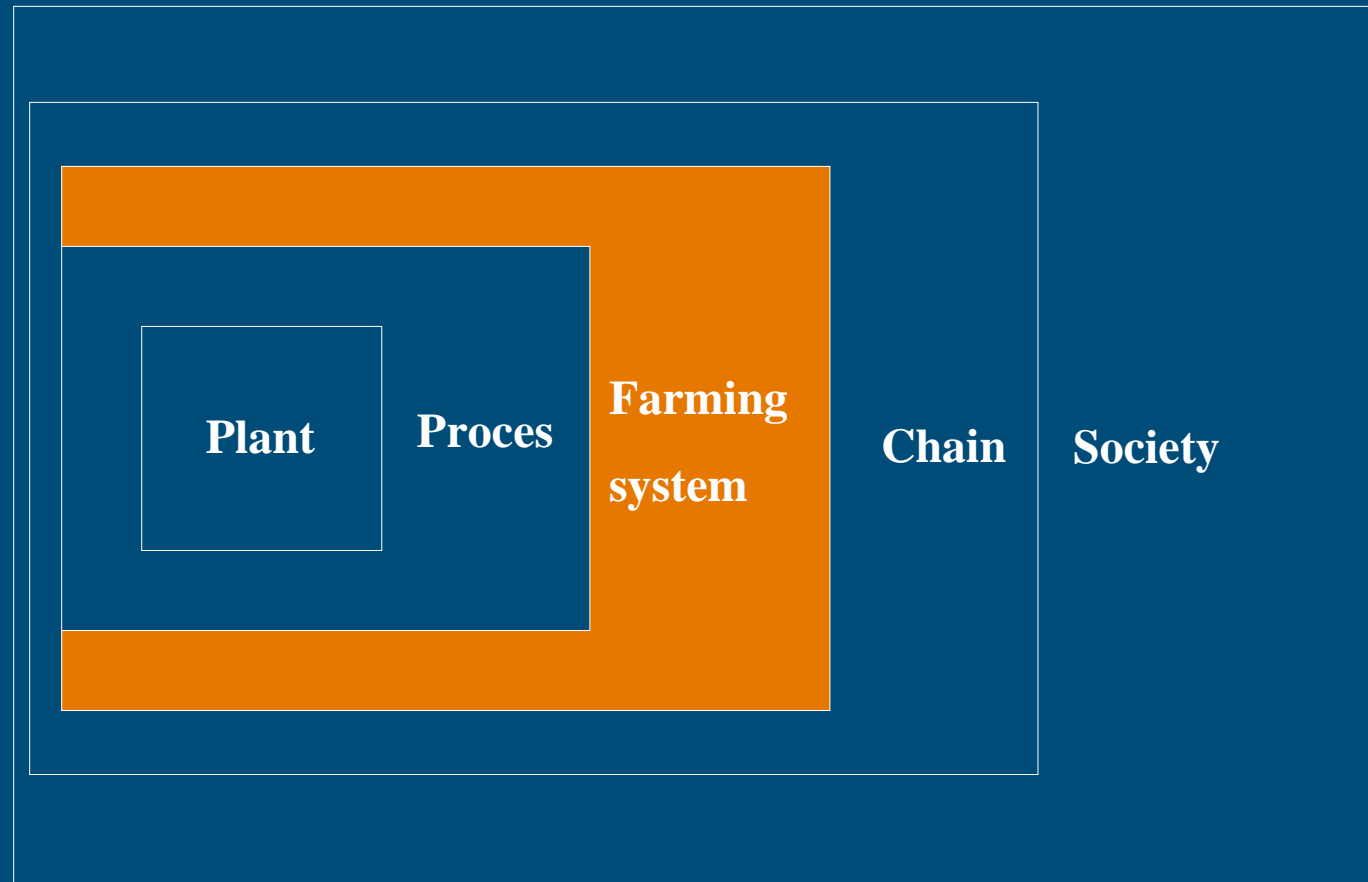
Methodology: prototyping

- Methodical way to innovation from a technological perspective
- System level - system innovation





System innovation





Prototyping (Vereijken)

- Analysis en Diagnosis
- Design
- Testing and Improving
- Dissemination and implementation



Analysis and diagnosis

- Regional farmstructure
- Constraints
- Policy and regulations
- Future developments



Design

- Establish objectives
 - Measure them with Yardsticks (parameters) and
 - Quantify them with target values
- Design farming methods
- Design operational plan

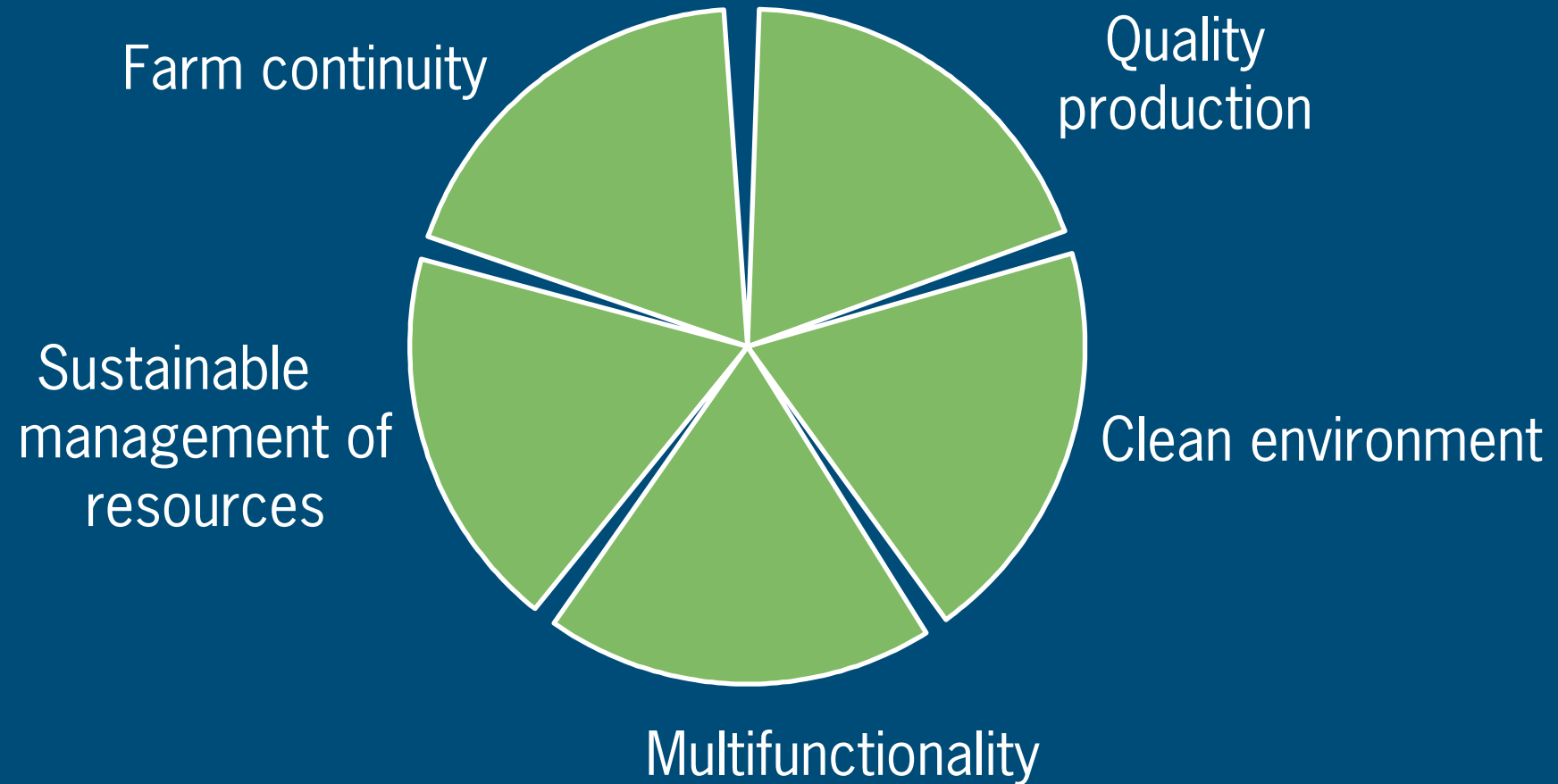


Design: Objectives/values

- Abiotic environment
- Food Supply
- Nature and Landscape
- Basic income/profit
- Health well-being
- Integrity of life
- Employment
- Others??



Design: Thematic approach





Design: Themes and parameters

- Farm continuity
 - Net profit
 - labour input (specified topics)

- Quality production
 - quantity and quality of produce

- Multifunctionality (in relation to on farm nature)
 - no of target species, no of target biotopes
 - infrastructure, area, connectivity, circuitry



Design: Themes and parameters

- Sustainable use of resources
 - use of (fossil) energy and mineral P and K
 - soil fertility, soil cover, soil health

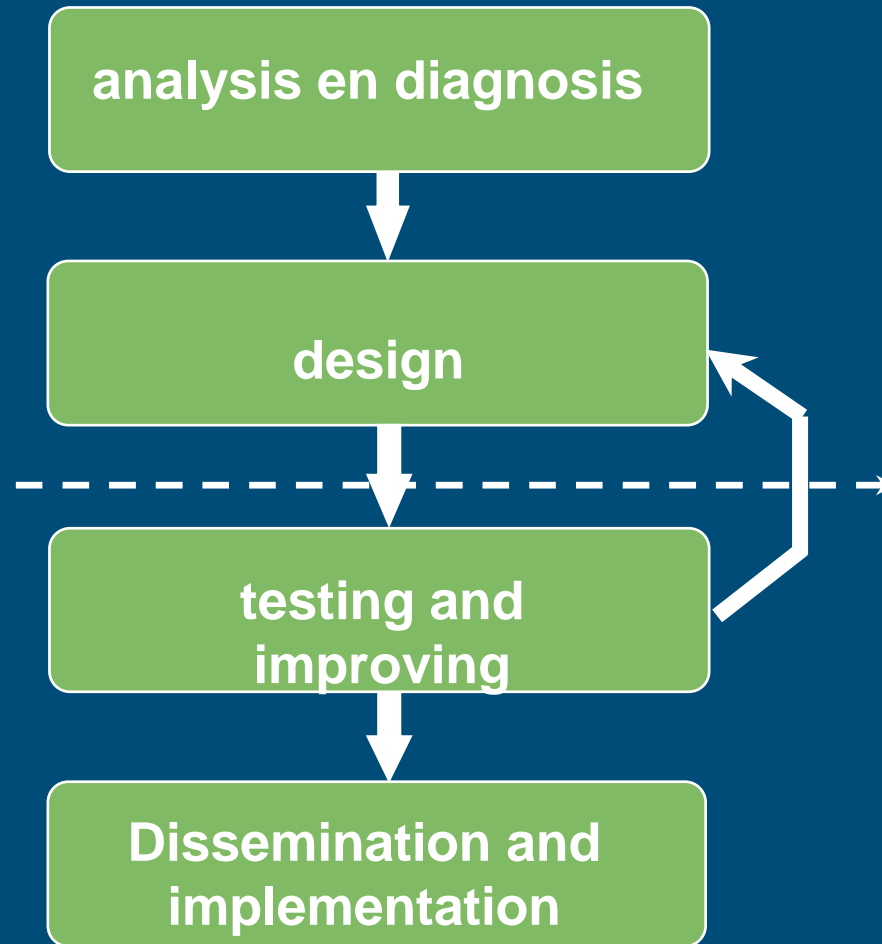
- Clean environment
 - use, emission and damage risk pesticides
 - use, surplus and emission nutrients
 - gas emissions



Our technical toolbox: Farming methods

Agronomic Toolbox to realise values

- Crop rotation
- Soil cultivation
- Fertilisation/Nutrient management
- Crop protection
- On farm nature (biodiversity) management





Prototyping, testing and improving

Test:

- lay out of prototype in practice
- measure results
- establish shortfall between target and result
- analyse cause in relation with methods

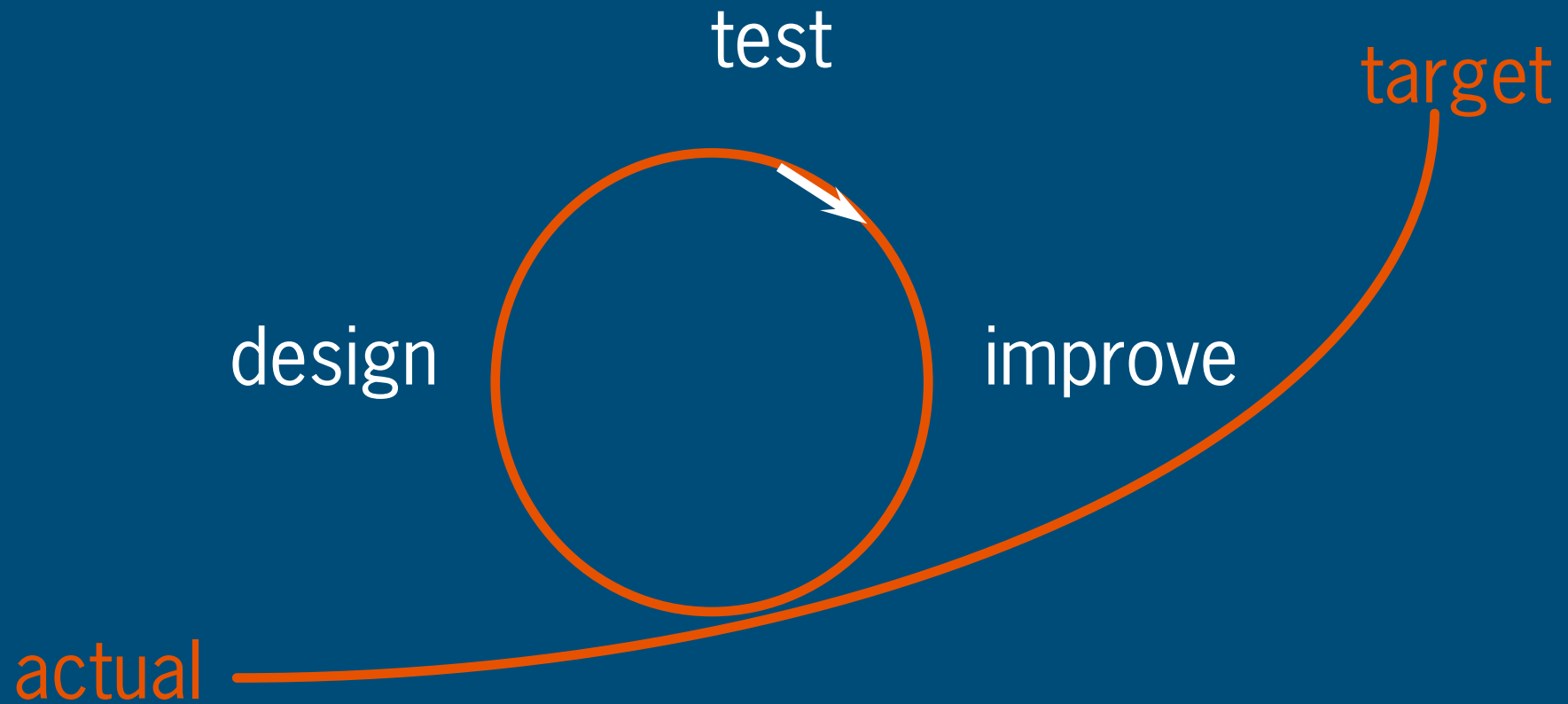
Improve

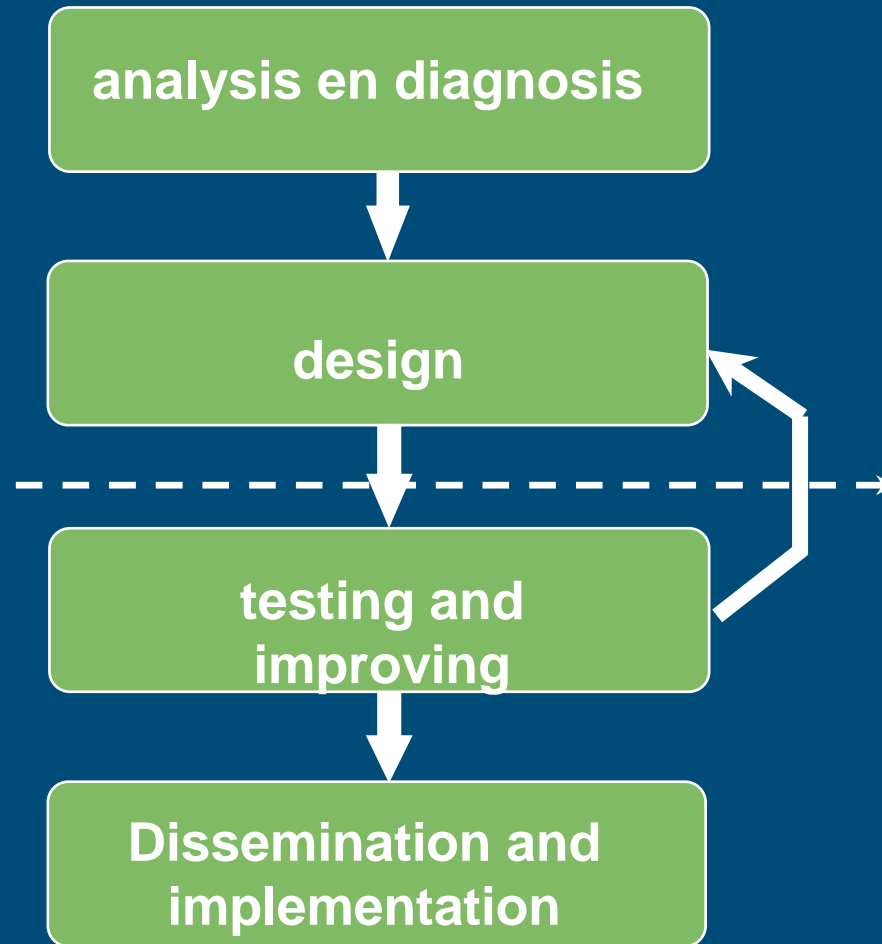
- focussed adjustment of farming methods

untill target results have been achieved



Testing and improving







Prototyping, dissemination and implementation

- Coöperation
 - research, extension and practice
- Testing and improving systems in practice
 - manage ability
 - acceptability
- Demonstration
- Participatory learning
 - farmer field schools, study groups



Results prototyping

- Potential performance in terms of yardsticks
 - Legislation, certification
- Set of farming methods
 - Certification, advice, best practices
- Insight in bottlenecks and processes
- Remaining need for socio-political solutions



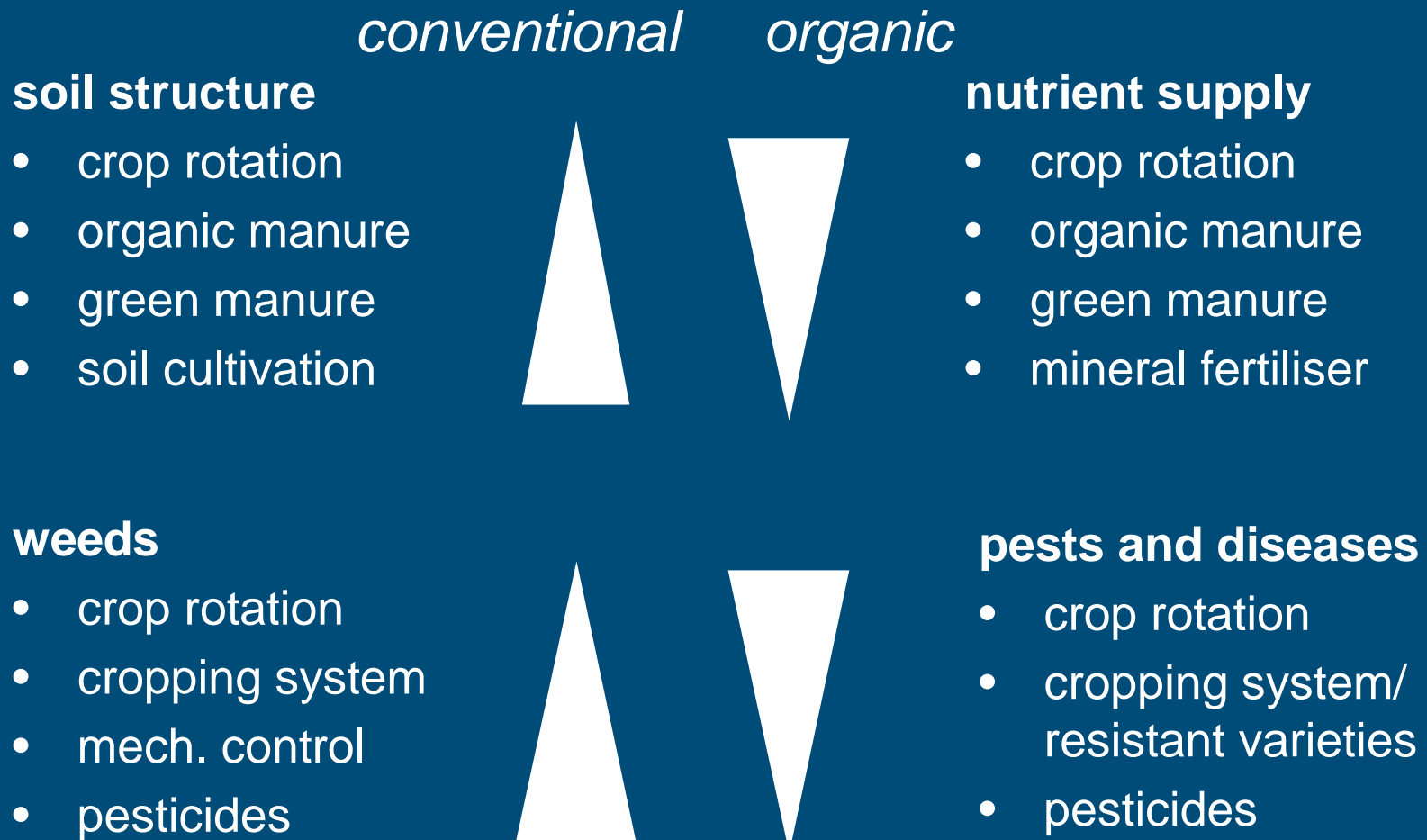
Farming methods

- General strategy (concept)
- Toolbox of methods and techniques
- Flexible integration into approach
- Region and farm specific interpretation of these strategies

- Objective: excellent agronomy

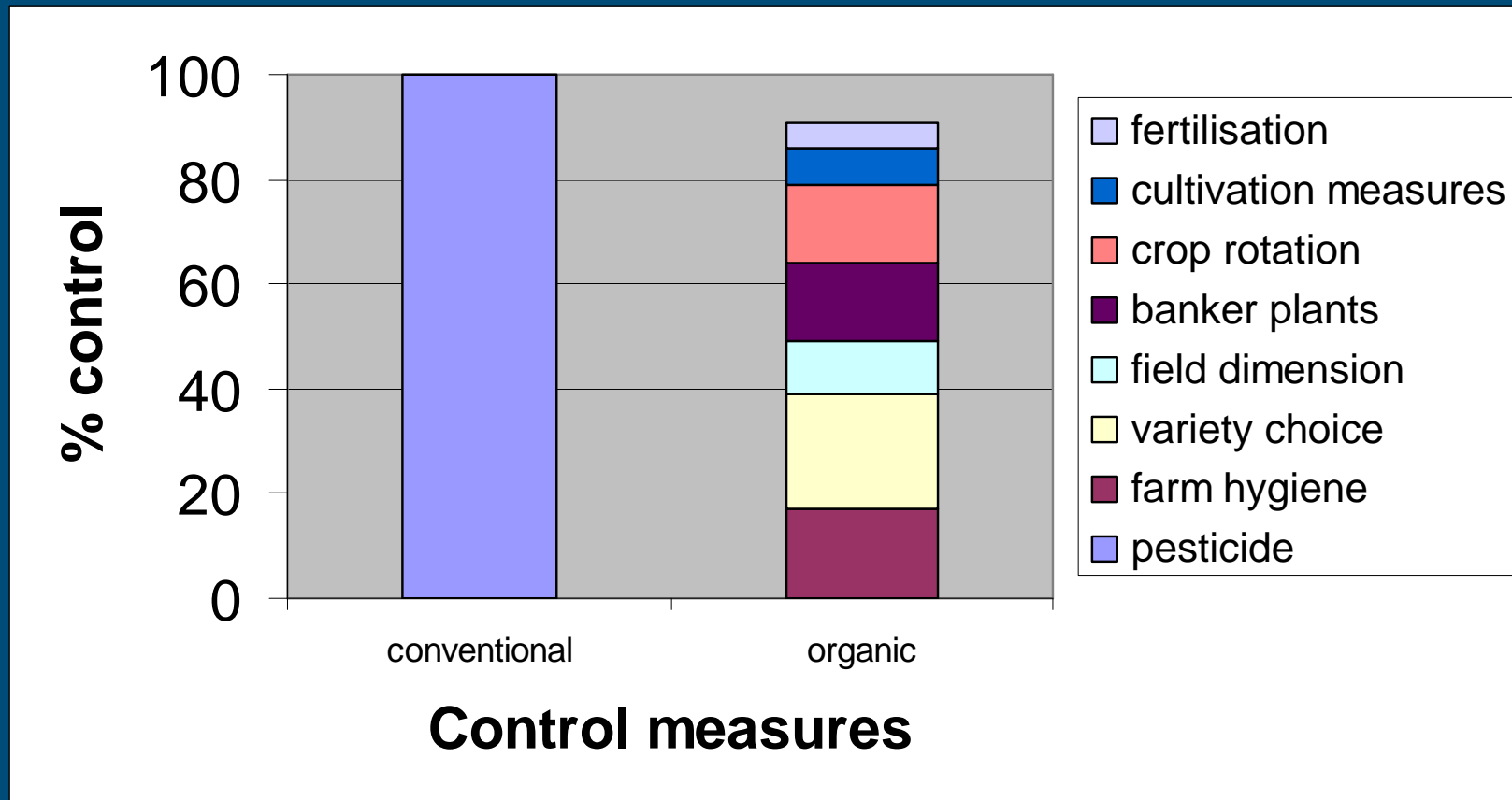


Emphasis in farming methods





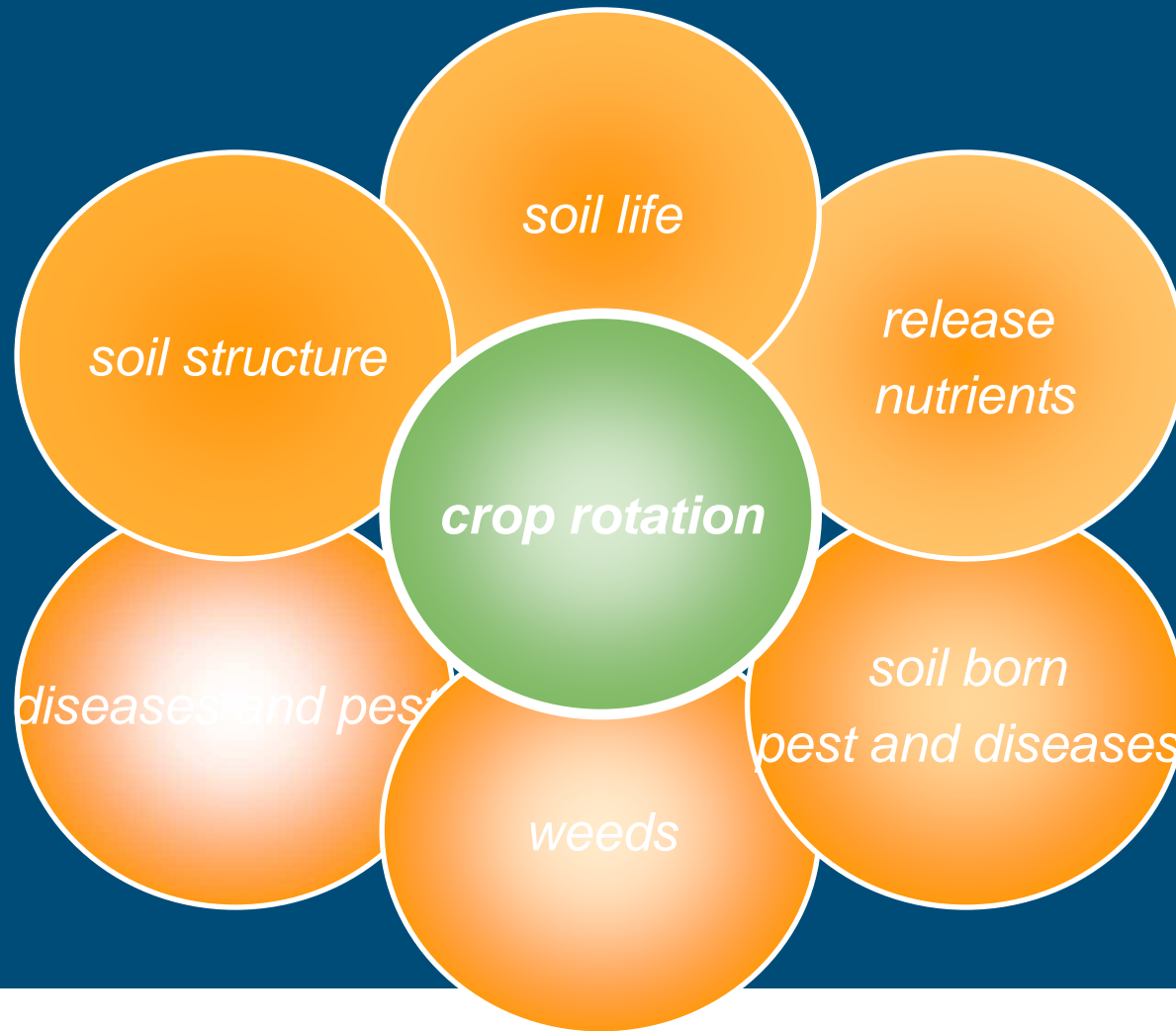
Complex and multi-objective methods



Control pest x (+ landscape + biodiversity + ...)



Influence crop rotation





Multifunctional crop rotation

■ basis for quality production

supported by:

- cropping systems
- crop protection
- on farm nature management and farm design
- fertilisation
- soil cultivation

■ crop rotation is a team of players



Crop rotation

- Crop choice (team of players)
- Crop frequency
- Crop sequence
- Spatial layout



Balanced Crop choice

- High and low nutrient demand
- Nitrogen fixating crops
- Intensive and superficial rooting
- High and low weed suppression
- High and low labour demand
- Different species and families

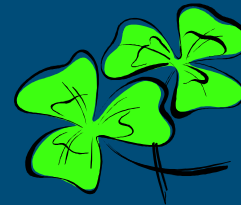


Crop Rotation Example

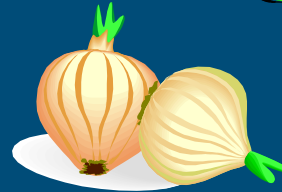
1. Potatoes



2. Grass/clover



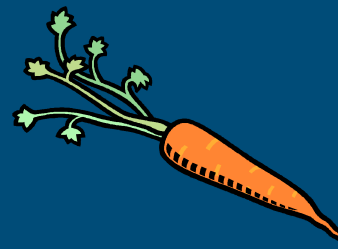
3. Onions



4. Springwheat



5. Carrots



6. Peas





Crop frequency, general recommendations

effective for crop specific soil born pests and diseases

- 1 in 6 for species
- 1 in 3 for families

- Take also green manures into account

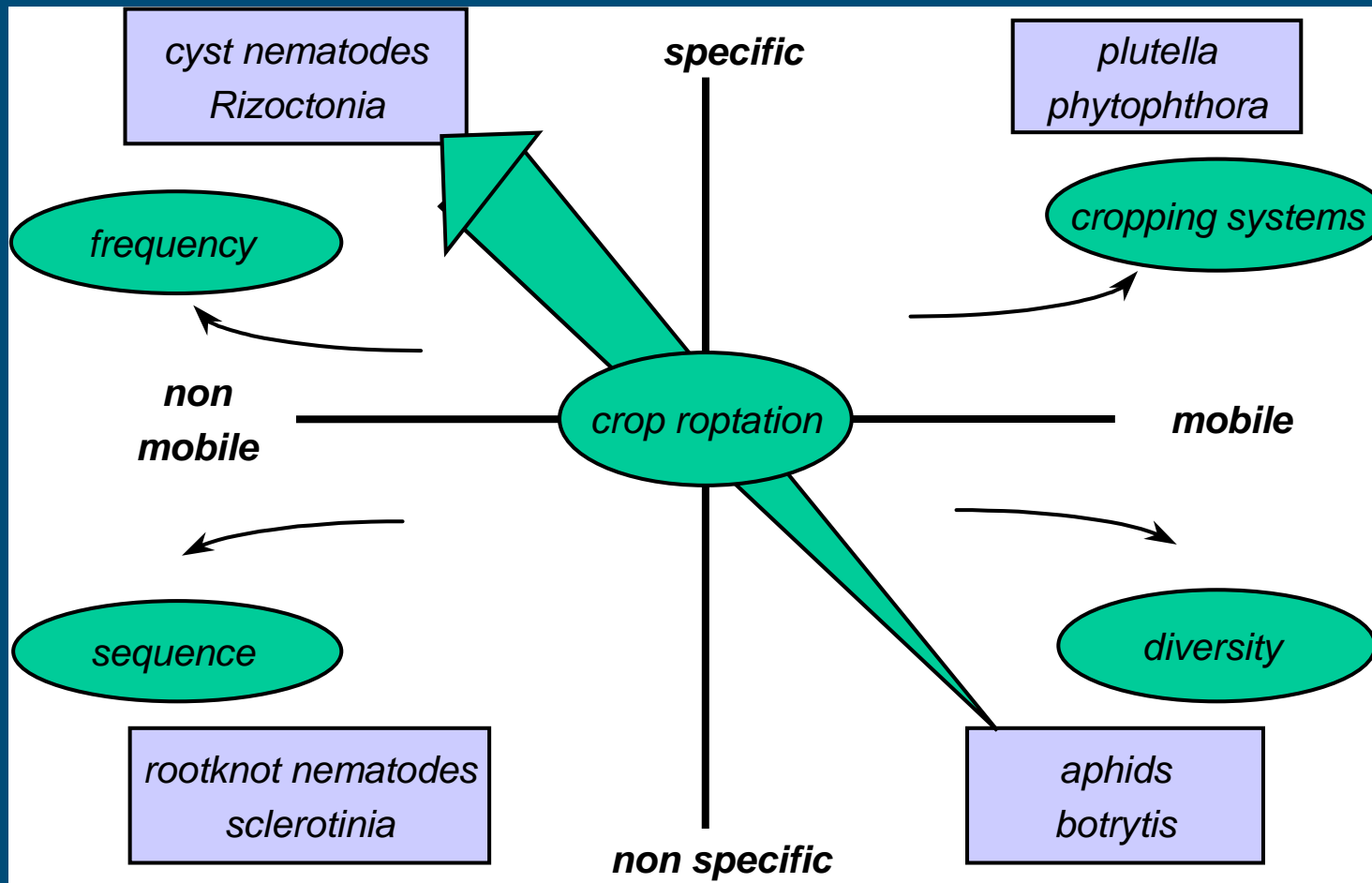


Crop sequence

- Soil structure
- Pests and Diseases
- Weed control



Crop Rotation, prevention of pests and diseases



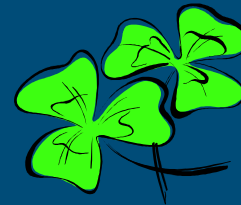


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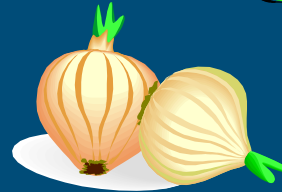
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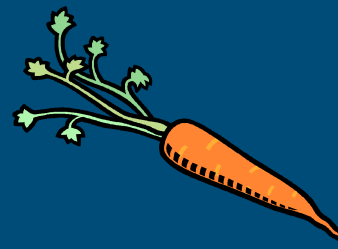
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Spatial crop rotation

Supports prevention of semi mobile, specific organisms as cabbage fly

1997

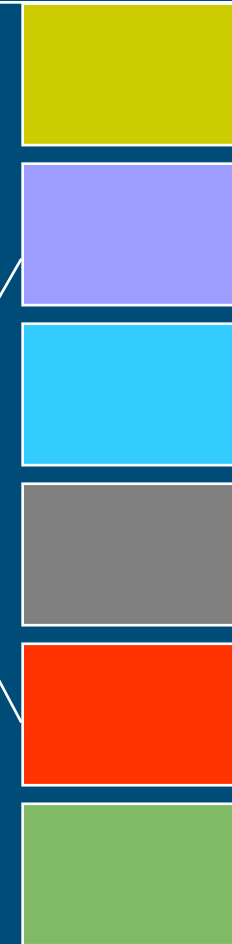


parcel 2

parcel 1

etc.

1998





Strategy crop protection

- Prevention
 - crop rotation, farm hygiene,...
- Need of control
 - asses if control is necessary
- Control
 - non-chemical control (mechanical, biological)
 - chemical,
 - pesticide selection
 - application technique



Prevention

- **Prevention of initial inoculum:**
 - • legal measures,
 - • farm hygiene and healthy seeds and plant material.
- **Enhancing (bio) diversity:**
 - • crop rotation and variety choice,
 - • design of the agro-ecological layout,
 - • other means of bio-diversification.
- **Creating unfavourable conditions for noxious organisms:**
 - • cultural methods,
 - • nutrient management.



Establishing need of control

- determine if organisms are harmful,
- monitor,
- prognosis of infestation or infection,
- prognosis of economic loss.



Control

- Physical
- Biological
- Chemical
 - pesticide choice
 - dose, timing and technique

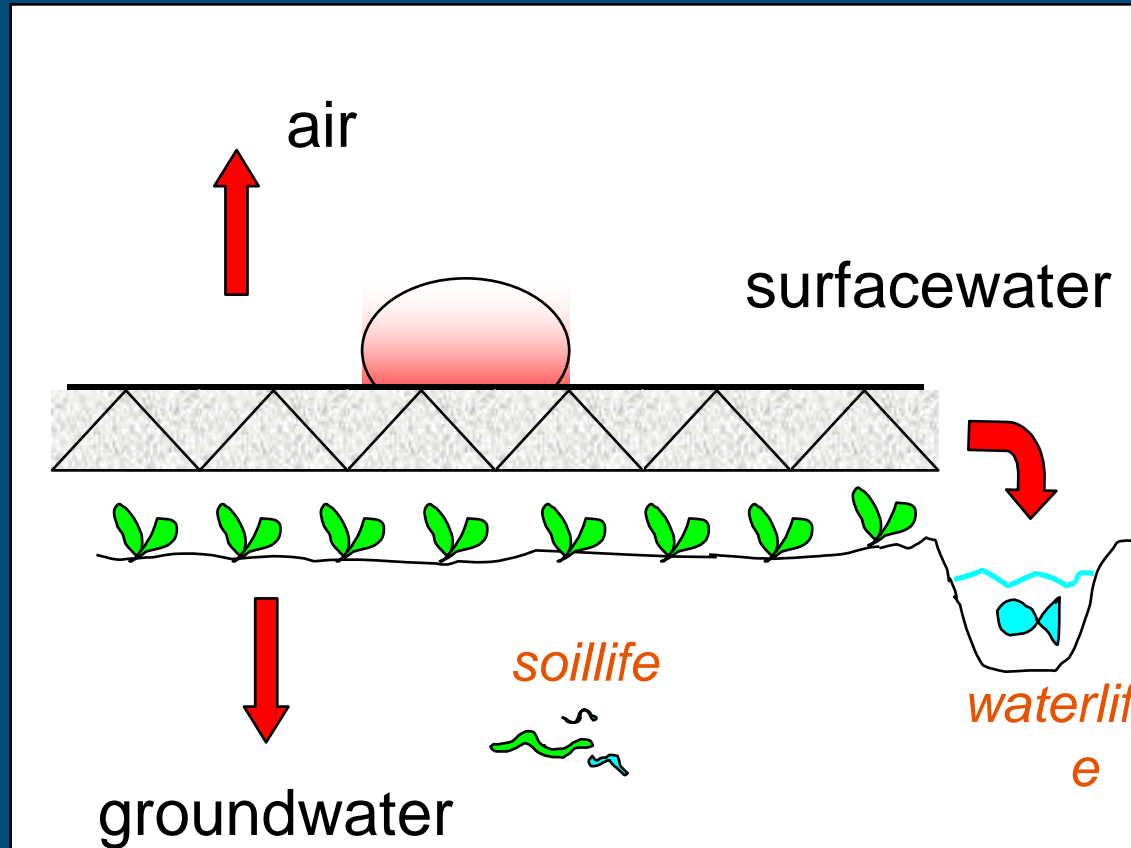


Chemical control

- Choice of pesticides
 - selectivity
 - resistance development
 - emission and damage risks
- Application
 - timing, weather conditions
 - application technique
 - dose



Environmental effects pesticides



parameters

use

emission

damage



Nutrient management

Principles:

- maintenance of soil fertility in agronomic desired and ecologically acceptable range
- $\text{input} = \text{of take} + \text{unavoidable losses for P and K}$
- $\text{nutrient losses} < \text{target values (EU norm)}$