APPLIED PLANT RESEARCH

Design of Farming Systems

Transition to Sustainable Agriculture

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Personal introduction

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

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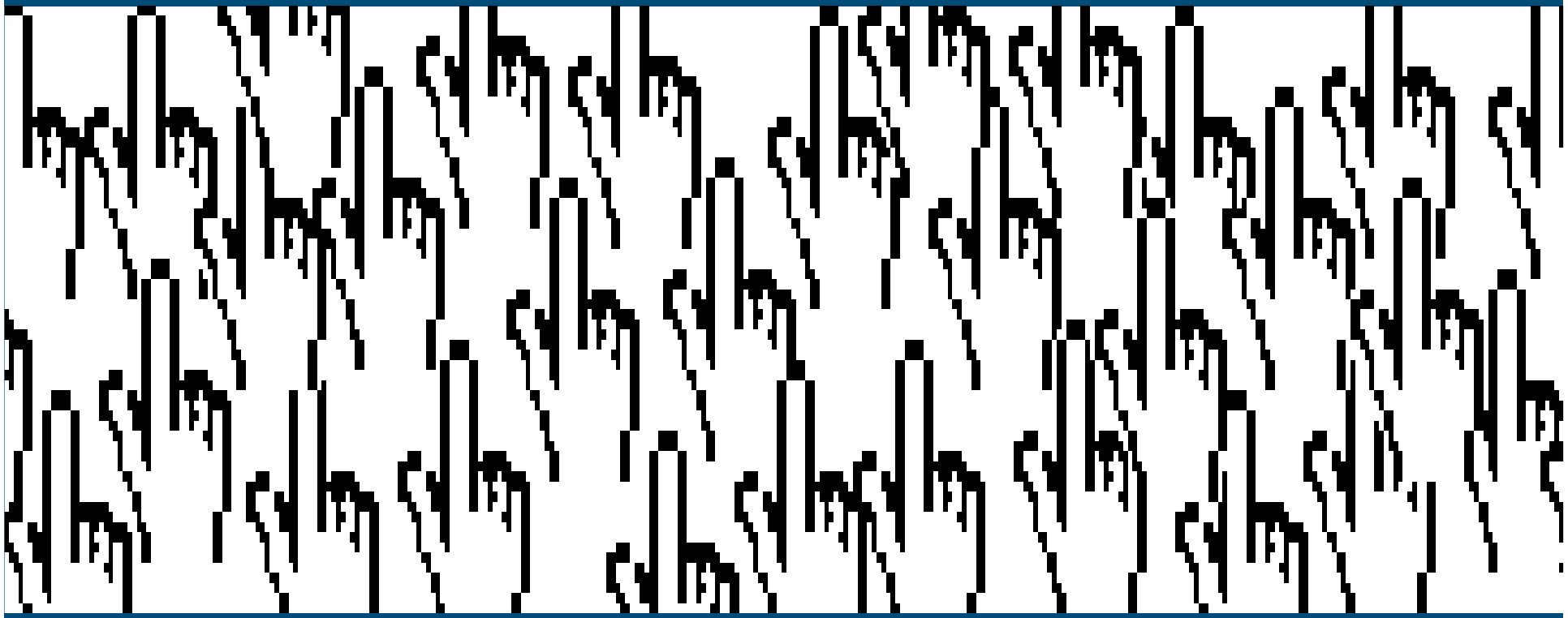
Questions?



Current Agriculture What's Wrong? Whats Right?

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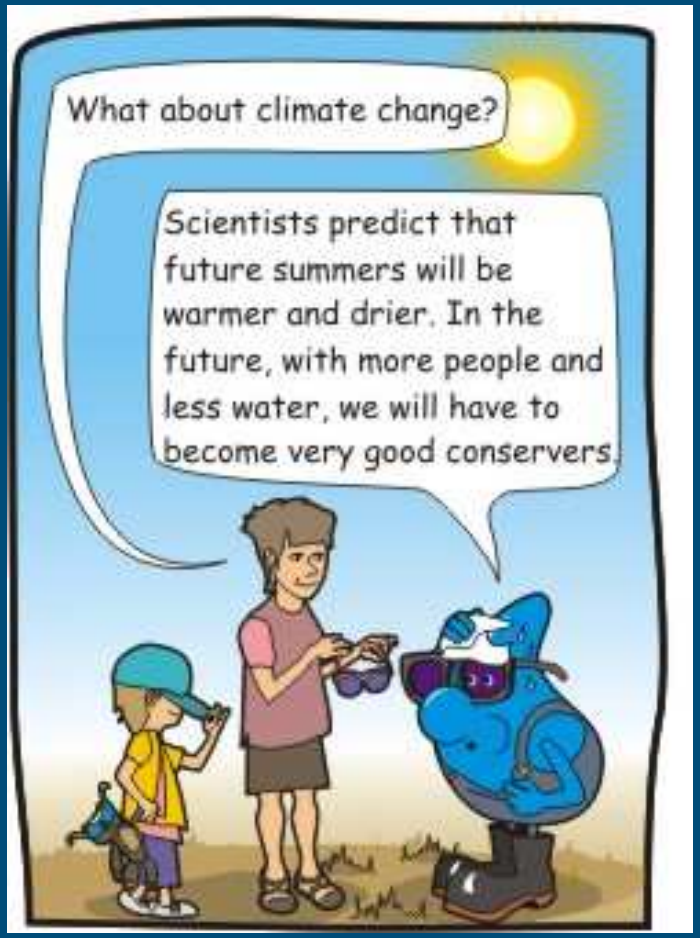
Adverse effects modern agriculture

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



The Agricultural Treadmill (Cochrane)

- Many farms all produce the same product
- None can influence price so everybody produces as much as possible for the going price
- New technology gives innovators windfall profits
- After some time others follow
- Increase of production and efficiency and decrease of price
- Who hasn't yet adopted the new technology has to follow otherwise he loses income
- Who cannot follow will stop. Their resources are absorbed by the innovators, scale enlargement

(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 nutriënts and pesticides
- decline of nature and landscape

Society

- concern for food safety
- claim for multifunctional land use

?

Something has got to change!

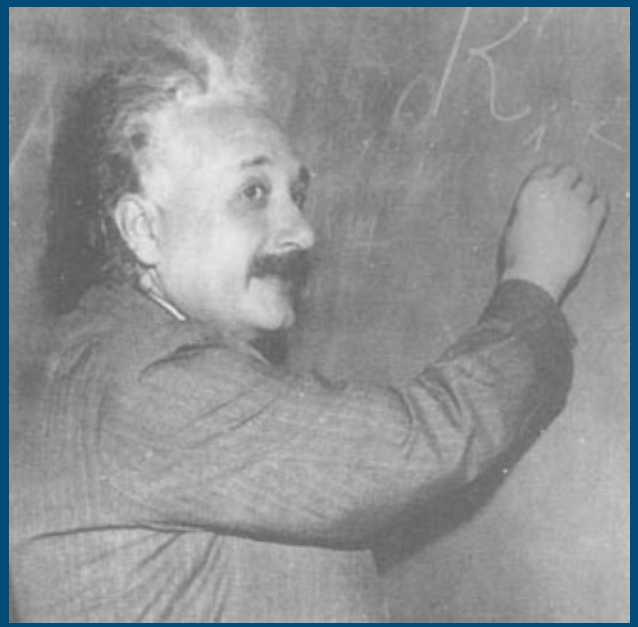
But how can we escape from the treadmill??

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
  - CO_2 sequencing
  - Water storage
  - Energy production
  - Recreation, Tourism
  - Silence, darkness
  - Health Care
  - .....

Main search directions

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

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 tredmill

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

(free interpretation Cochrane)

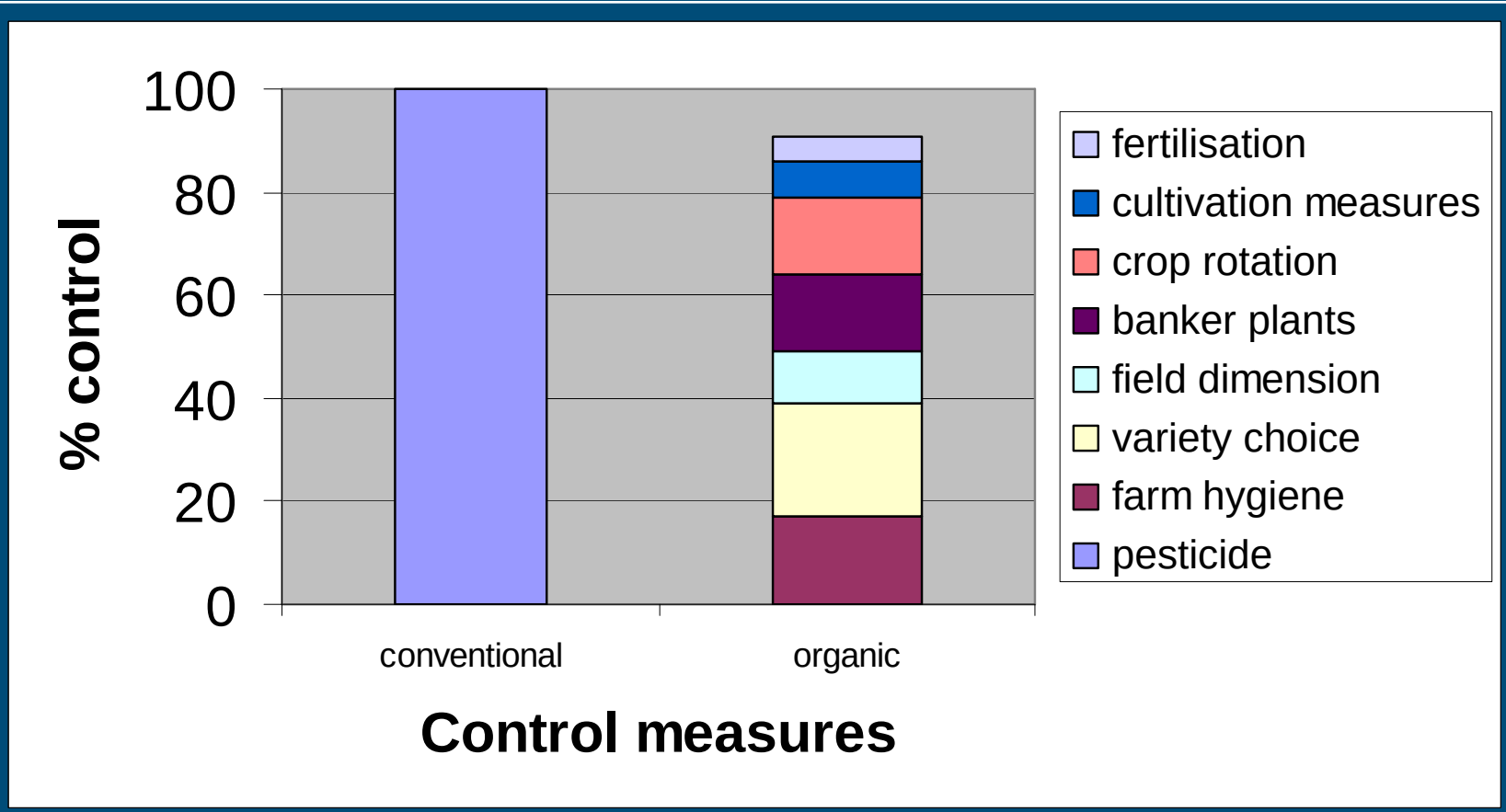
Coping with the conflict

- 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

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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

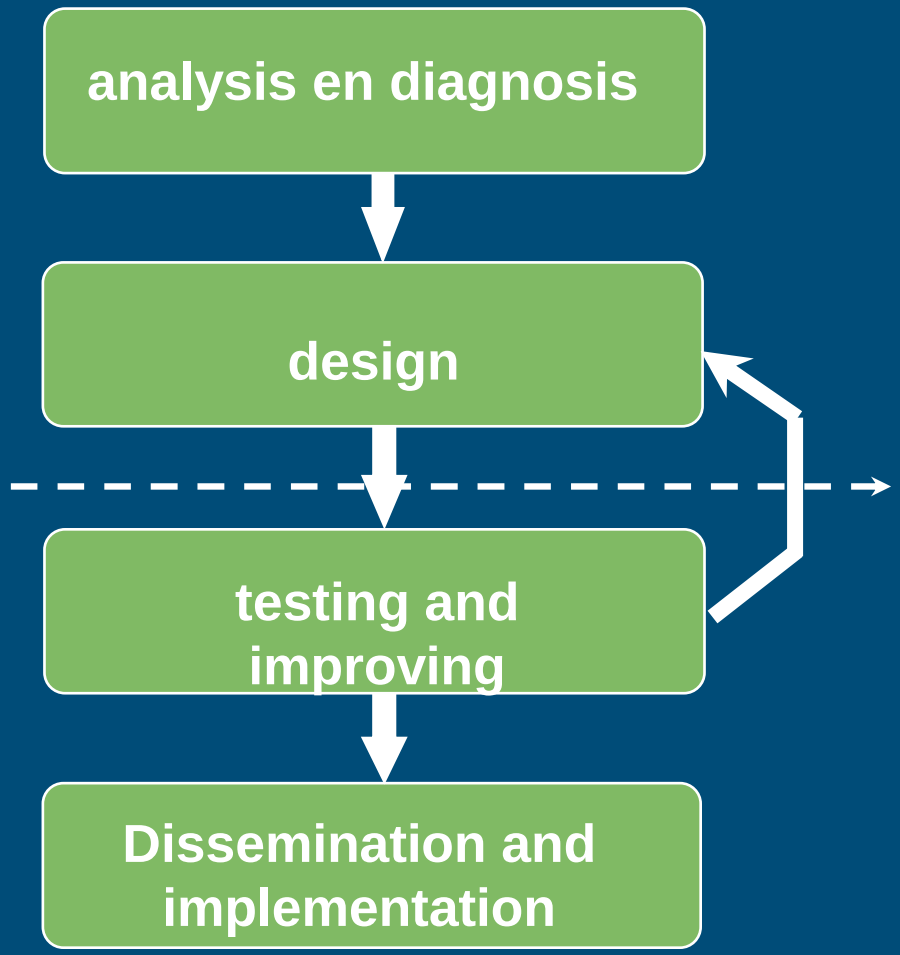
- System innovation: coherent overall concept, multi-objective
  - Agronomical
  - Ecological
  - Economical
- Integrated technology
  - agro-ecological principles, agronomy and technology Whole farm

Main search directions

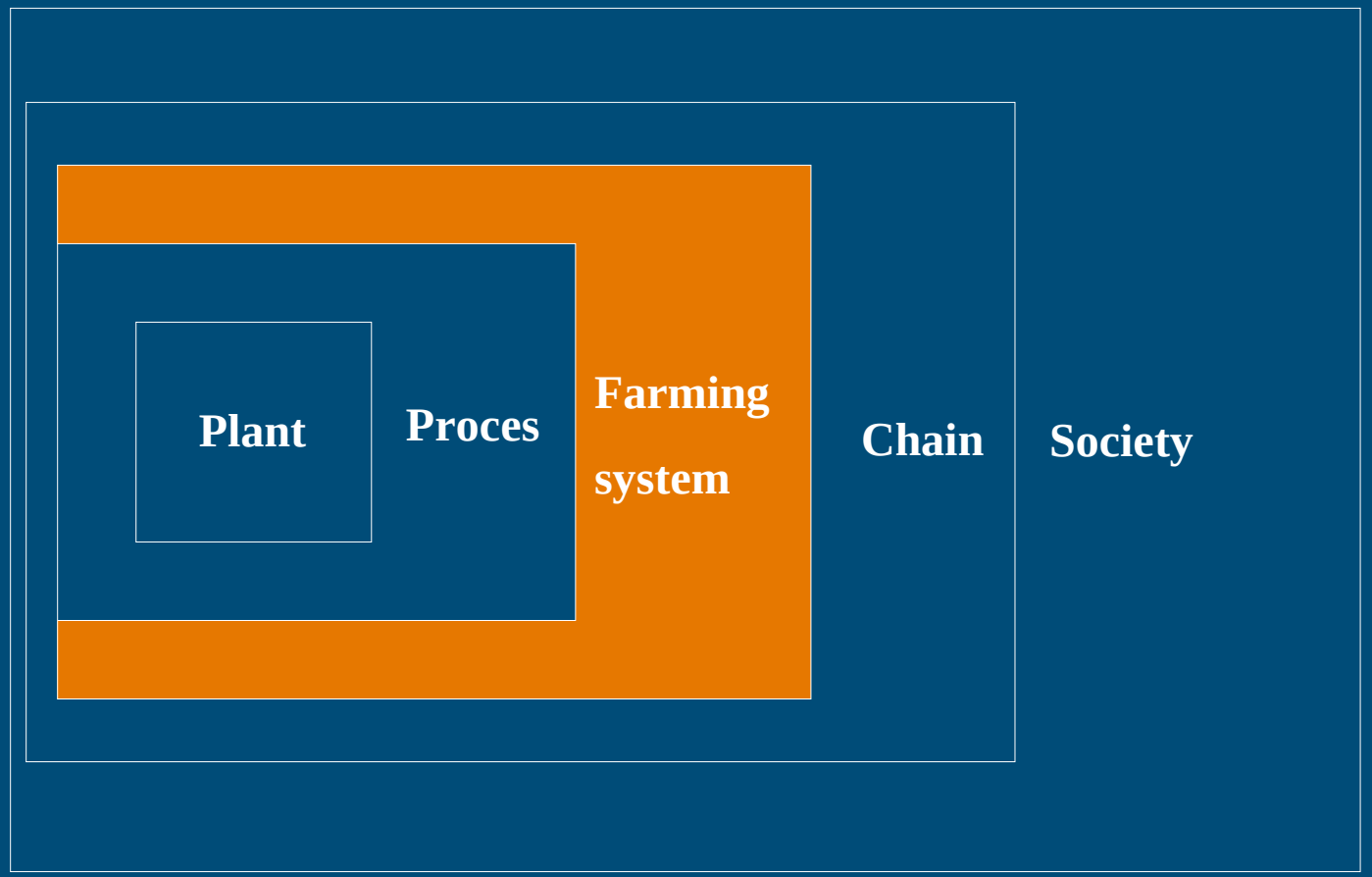
- Conventional agriculture
  - Food production, income
- Integrated agriculture
  - Food production, income, environment, ending resources
- Conservation agriculture
  - Food production, income, environment, ending resources
- Organic agriculture
  - Food production, income, environment, ending resources,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

Methodology: prototyping

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



Systeem innovation



Prototyping (Vereijken)

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

Analysis and diagnosis

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

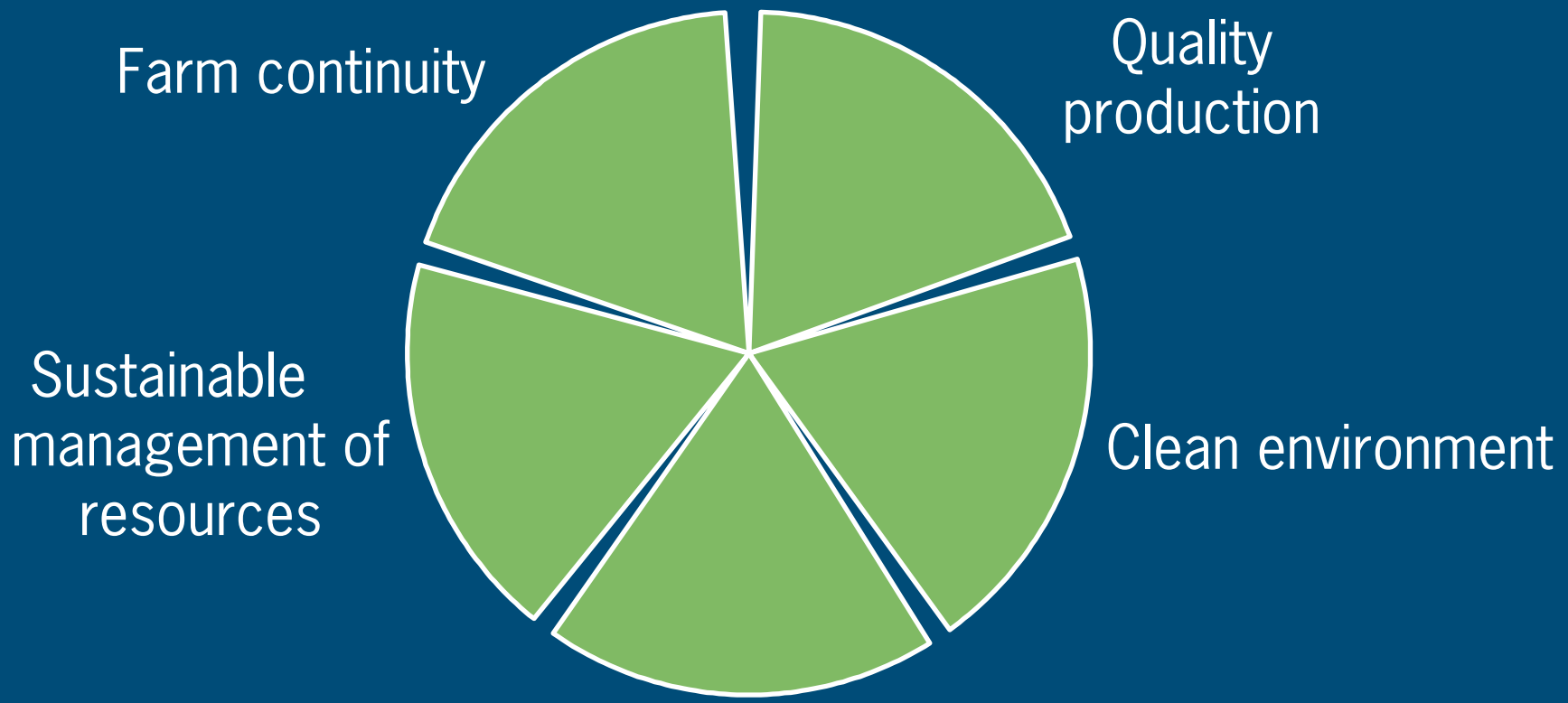
Design

- 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

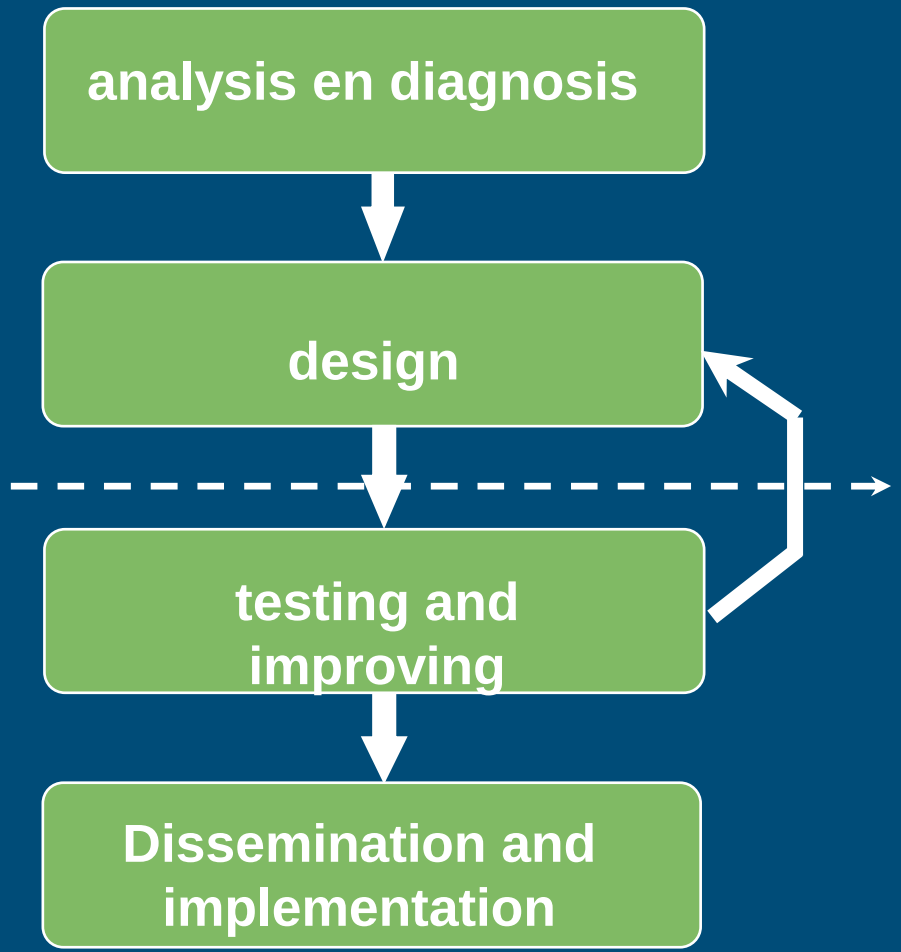
Design: Themes and parameters

- 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


analysis en diagnosis
design
testing and improving
Dissemination and implementation

Prototyping, testing and improving

Test:

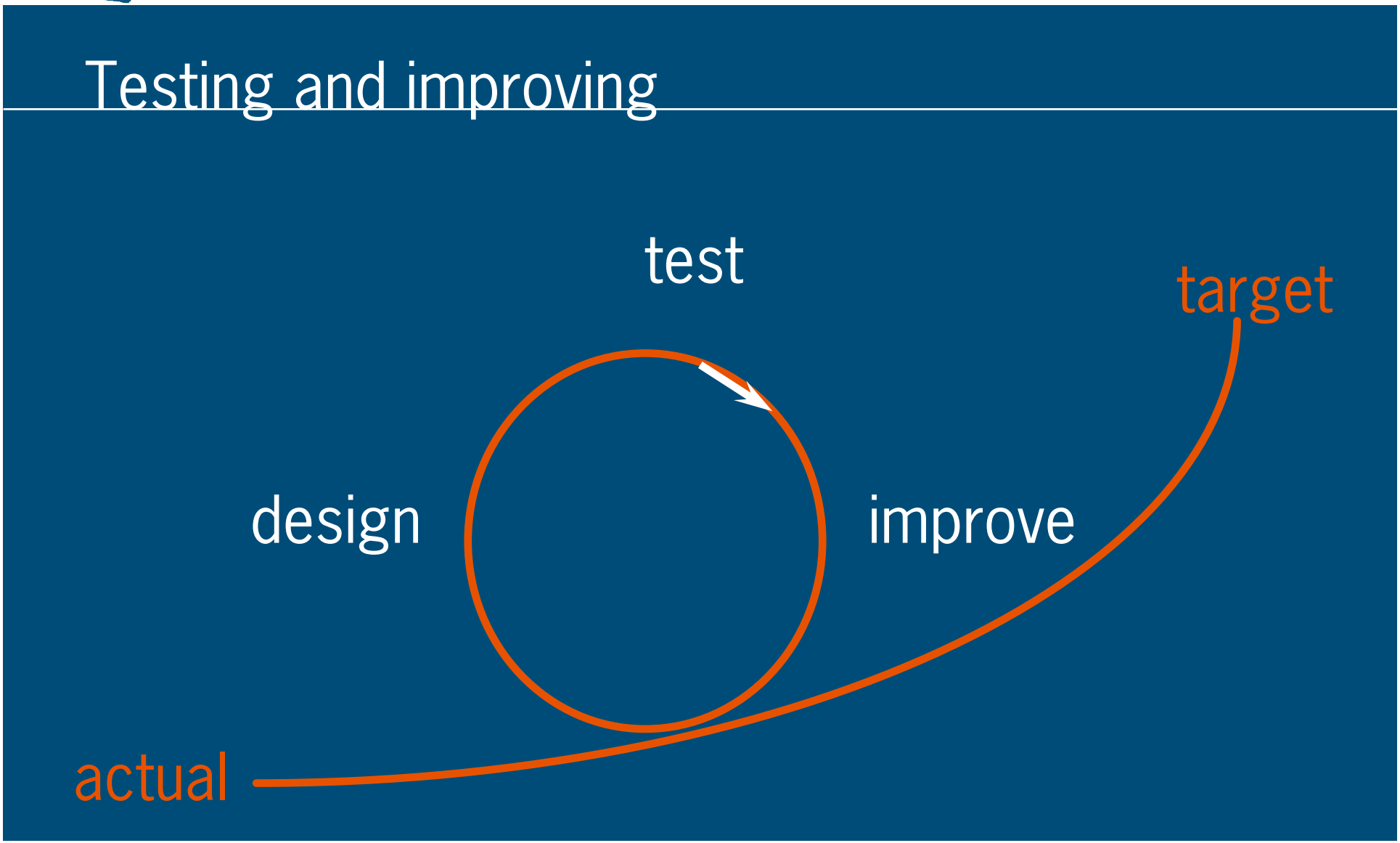
- lay out of prototype in practice
- measure results
- establish shortfall between target and result
- analyse cause in relation with methods

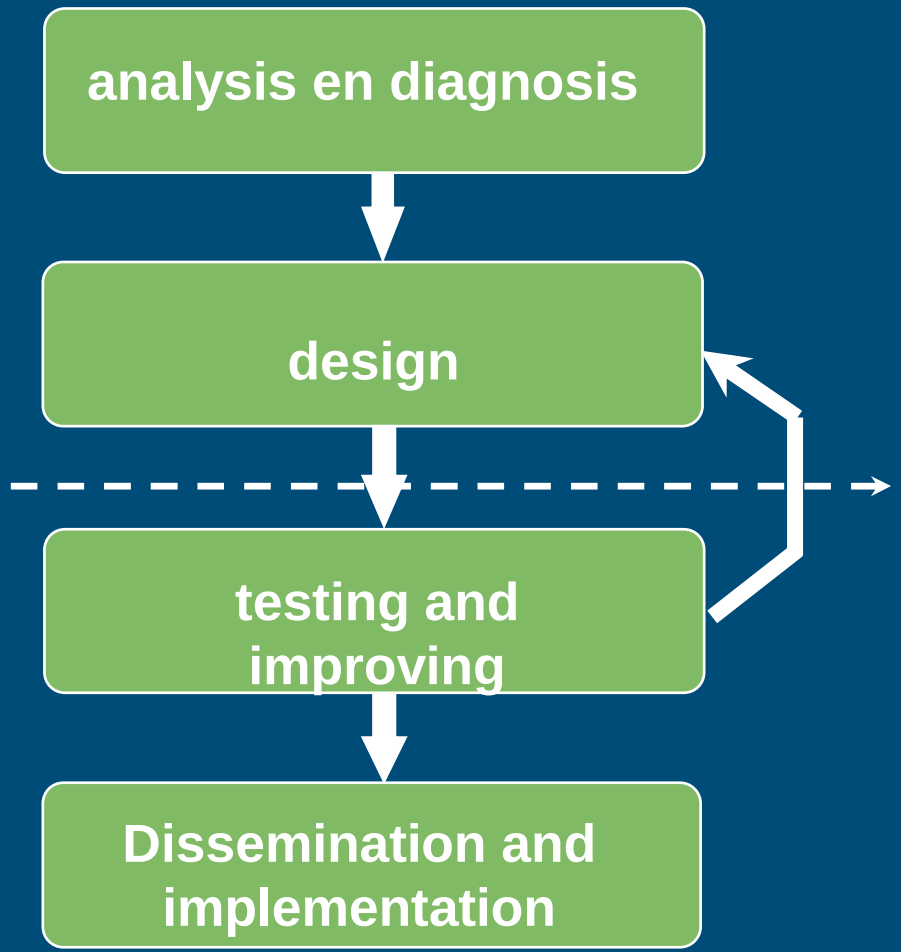
Improve

- focussed adjustment of farming methods

untill target results have been achieved

Testing and improving




analysis en diagnosis
design
testing and improving
Dissemination and implementation

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-opolitical 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

conventional *organic*

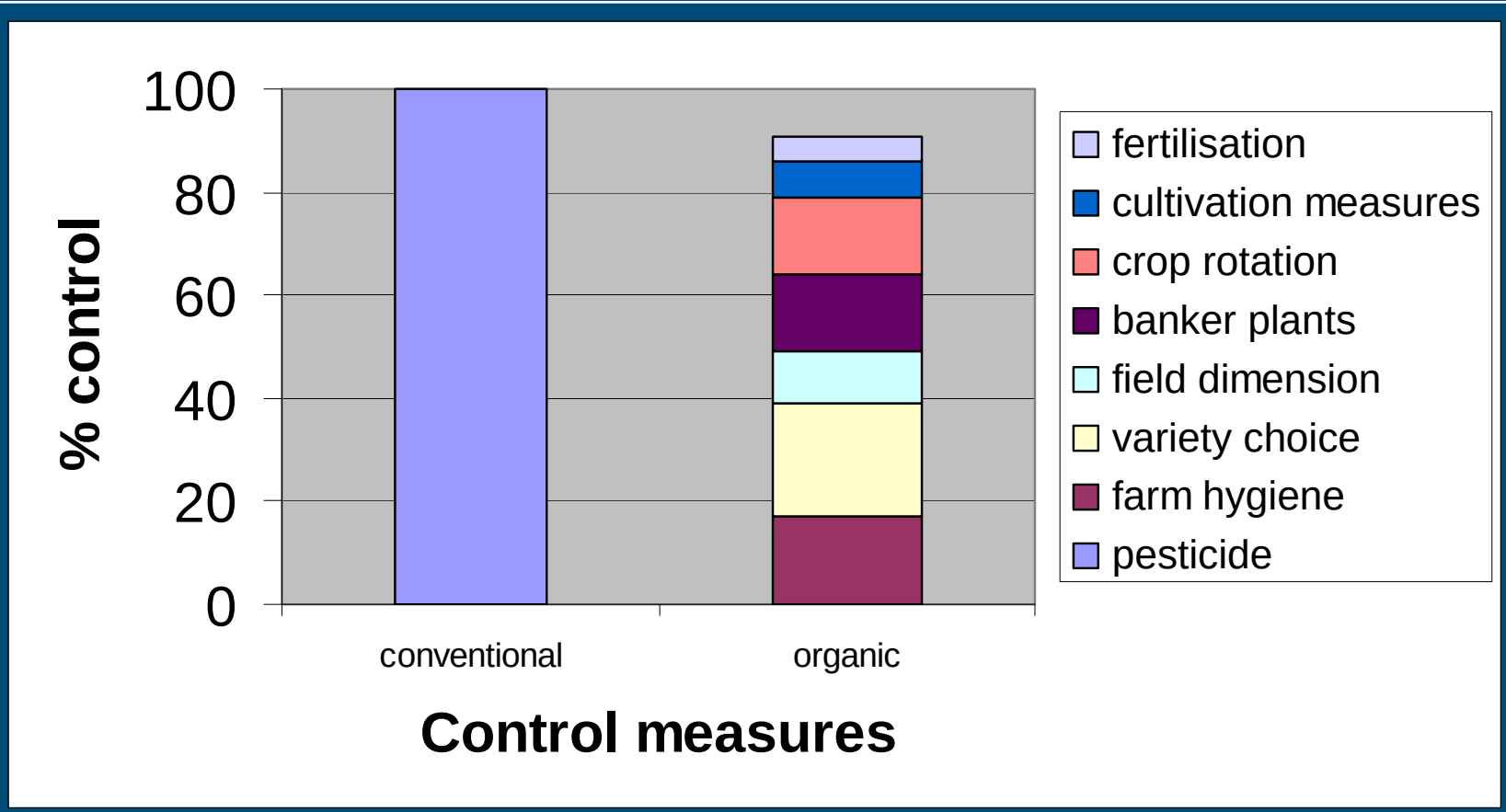
soil structure
- crop rotation
- organic manure
- green manure
- soil cultivation

nutrient supply
- crop rotation
- organic manure
- green manure
- mineral fertiliser

weeds
- crop rotation
- cropping system
- mech. control
- pesticides

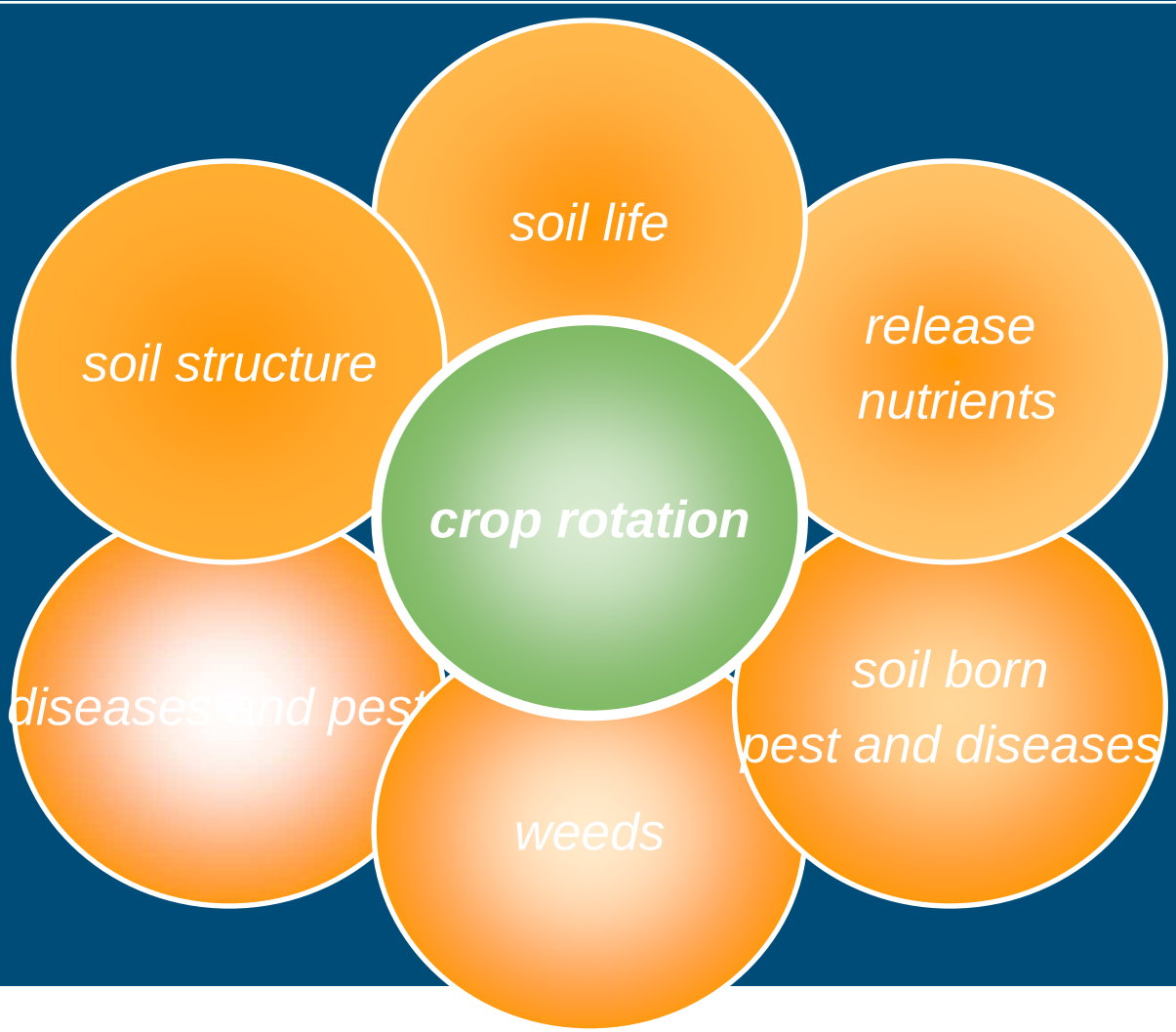
pests and diseases
- crop rotation
- cropping system/ resistant varieties
- pesticides

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

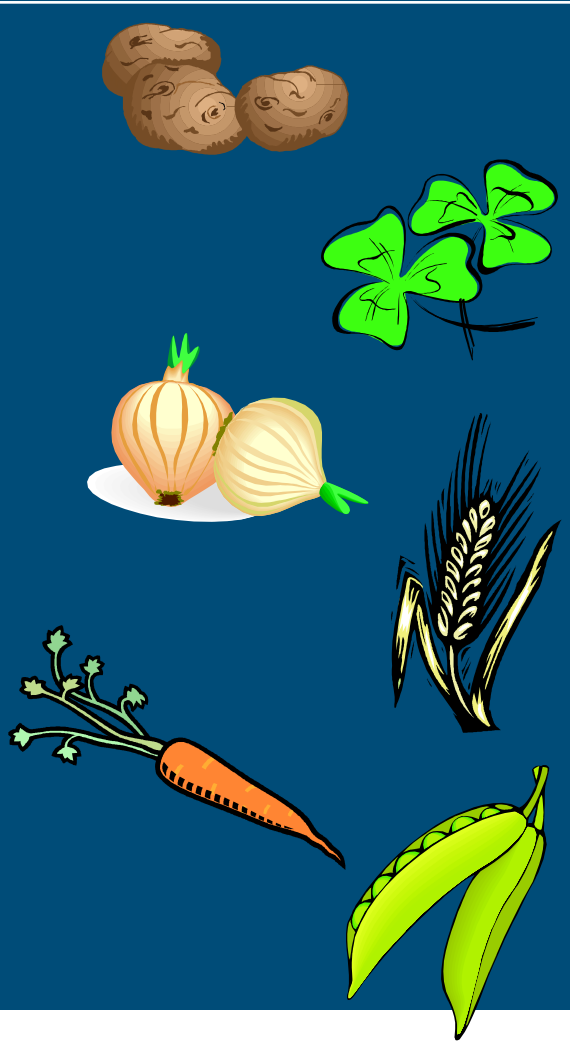
- Crop choice (team of players)
- Crop frequency
- Crop sequence
- Spatial layout

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

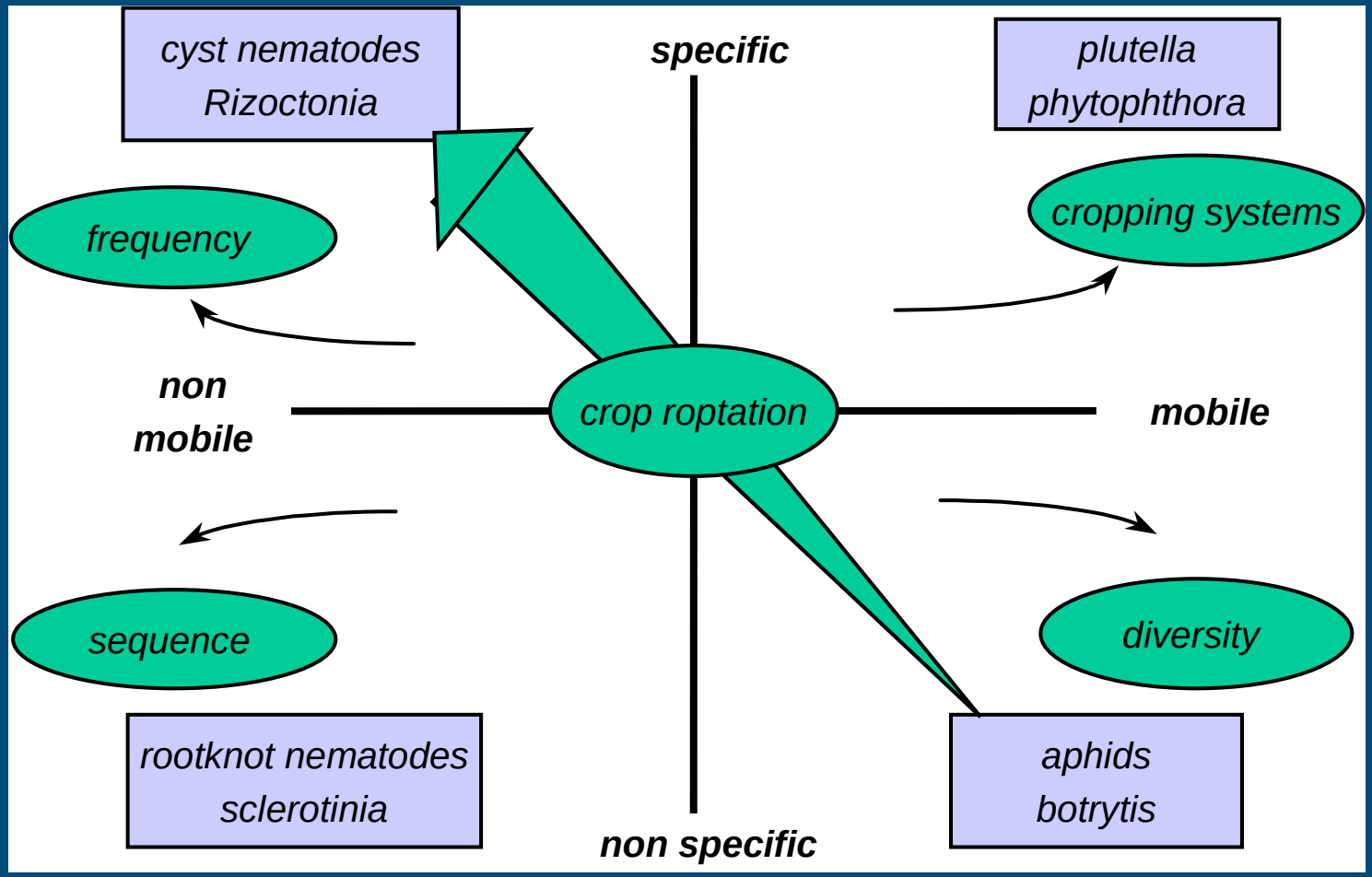
- 1 in 6 for species
- 1 in 3 for families

- 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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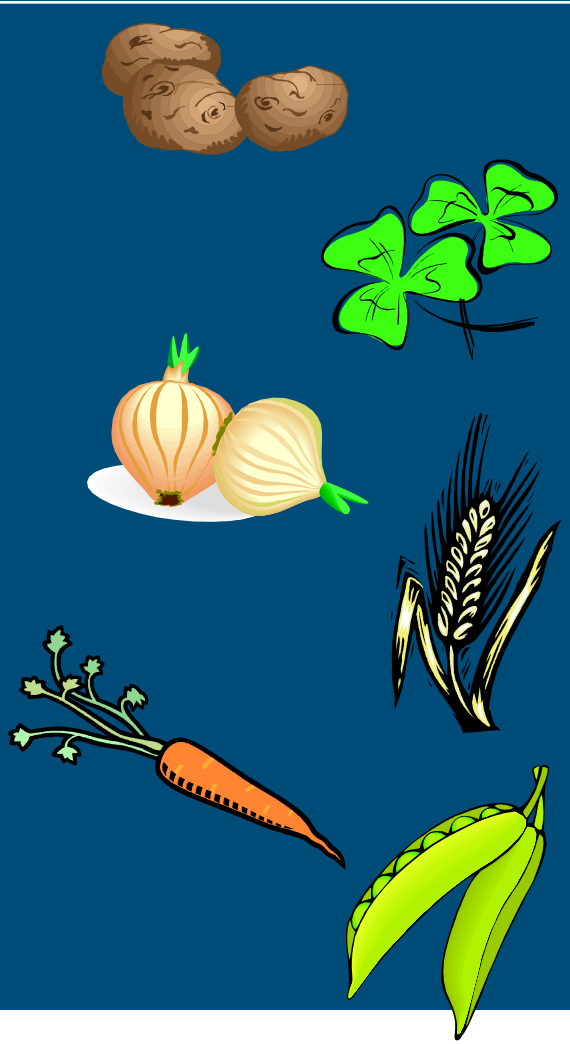
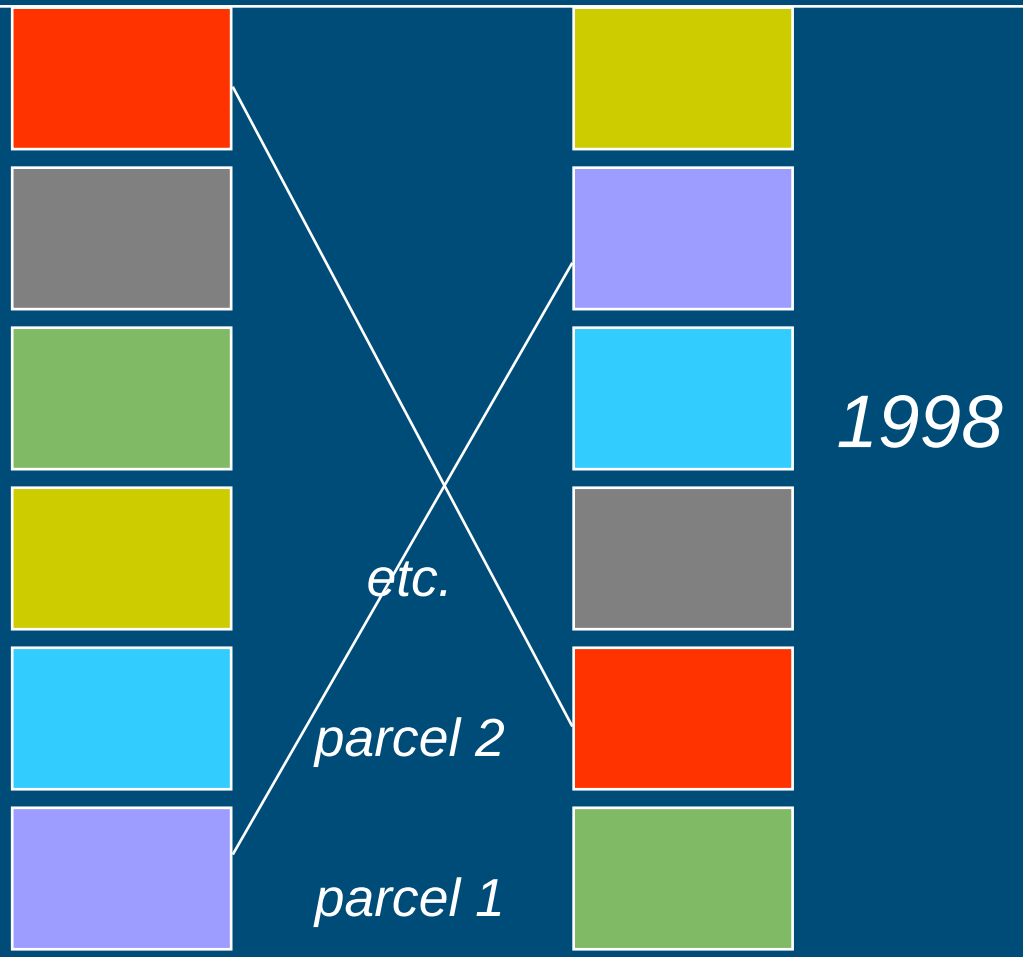


Spatial crop rotation

Supports prevention of semi mobile, specific organisms as cabbage fly



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.

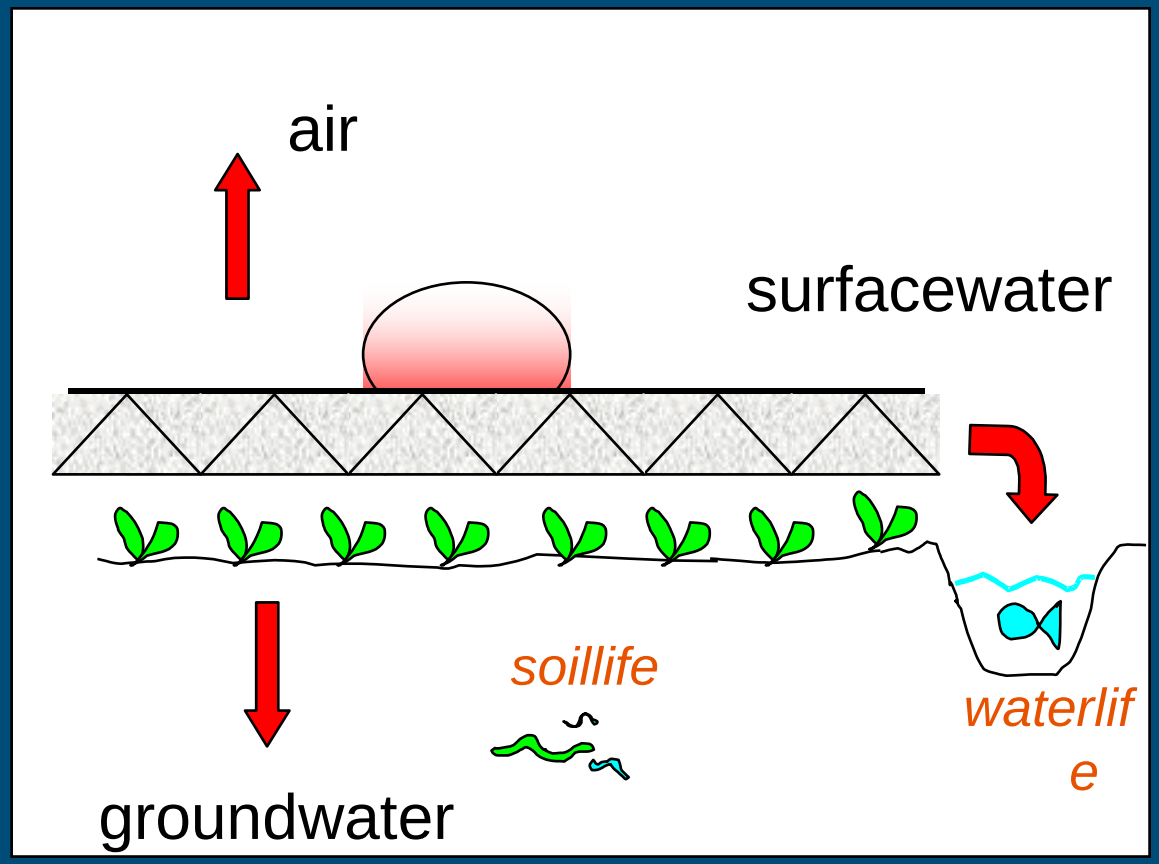
Control

- 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
- input = oftake + unavoidable losses for P and K
- nutrient losses < target values (EU norm)