
SLU
SCIENCE AND EDUCATION FOR SUSTAINABLE LIFE

# Crop protection in a systems perspective

Göran Bergkvist, SLU

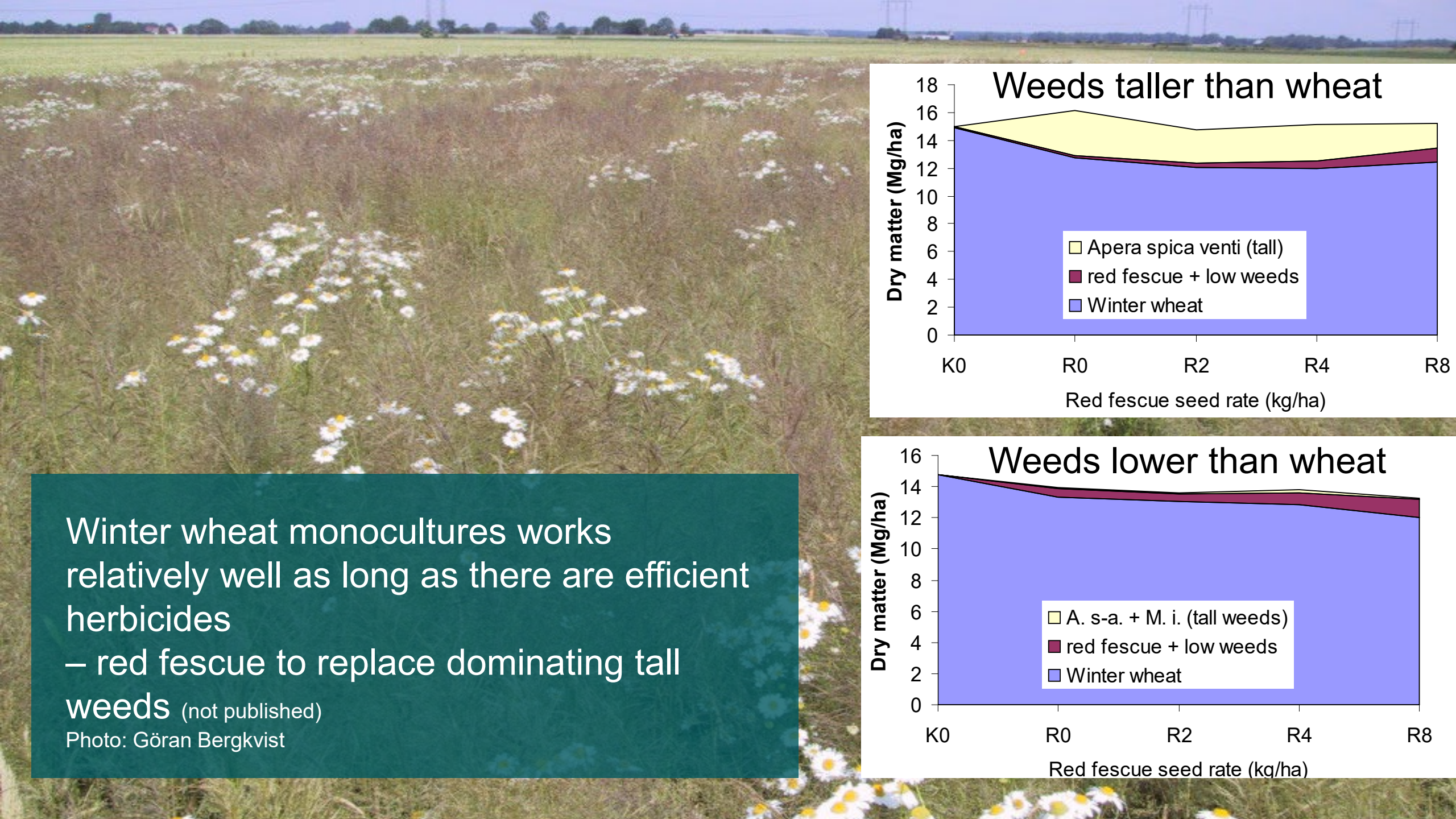
1. An ecological approach to regulation of weeds, pests and diseases
2. Illustrated knowledge gaps based on field experimentation
3. Some ideas regarding long term experiments

# Winter wheat, winter wheat, winter...

Photo: Göran Bergkvist

# Weeds, pest and diseases as determinants of cropping systems

1. Efficient inputs replaced a balanced crop rotation and made specialisation possible.
2. Chemicals and intensive tillage are efficient filters for selection of weeds, pests and pathogens.
3. Weeds, pests and pathogens develop tolerance or resistance to chemicals.
4. Resistant weeds, pests and pathogens drives the development of new technologies or changes of cropping systems.



Winter wheat monocultures works relatively well as long as there are efficient herbicides
– red fescue to replace dominating tall weeds (not published)
Photo: Göran Bergkvist

# Diversification counteracts adaptation

Nöbbelöv, Östra Göinge 1970. Photo: Knut-Erik Persson

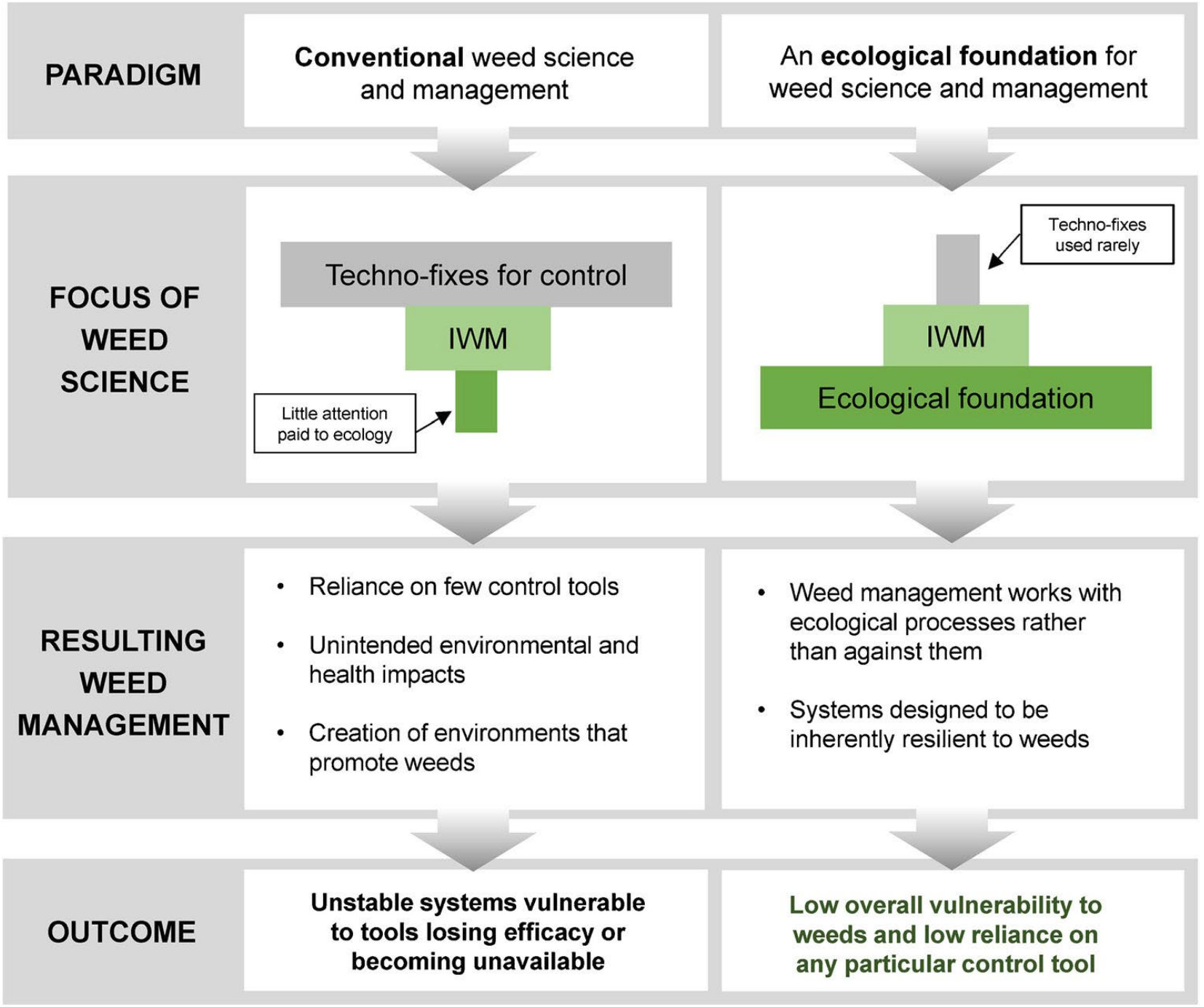
Distribution of animals in the landscape (consumer added value)

Lanna R4-1103, Västergötland. Photo: Göran Bergkvist

Perennial forage crops for biogas or other uses (industry and society)

Glyttinge, Linköping. Photo: Göran Bergkvist

Diversify cropping systems dominated by annual crops (in any concept)




# **Ecology – the science of agriculture in the 21st century** (Weiner 2003)

Ecological solutions require knowledge and precision, including technology

"Many little hammers" (Liebman and Gallandt 1997)

Transdisciplinary – ecology, agronomy, social sciences (Jordan et al. 2016; Kleijn et al. 2019)

From:
MacLaren et al. (2020)
Agronomy for Sustainable Development 40: 24

**Ex. Rye cover crop before grain legumes**

- N-competition
- Shading
- Allelopathy
- Barrier

Short term field experiments

Photo: Göran Bergkvist

## Ex. Undersown grass and clover combined with row hoeing

– multiple services: save N, contribute fixed N, competition with weeds, habitat for wild life and build soil fertility

Short term field experiments

Aronsson et al.(2015) Nutrient Cycling in Agroecosystems 102, 383-396.

Photo: Erik Ekre

**Ex. Hypothesis: The crop will benfit in competition with couch grass if the individual plant size of couch grass is reduced.**

Photo: Göran Bergkvist

# Vertical cutting benefit ryegrass that doesn´t have rhizomes compared to couch grass

Combining preventive practices (perennial ley) with curative direct control (vertical cutting)

Bergkvist et al. (2017) Weed Research 57, 172–181.
Ringselle et al. (2018) Front. Plant Sci. 8:2243.

Photo Göran Bergkvist

Kverneland prototype Photo Marcos Lana

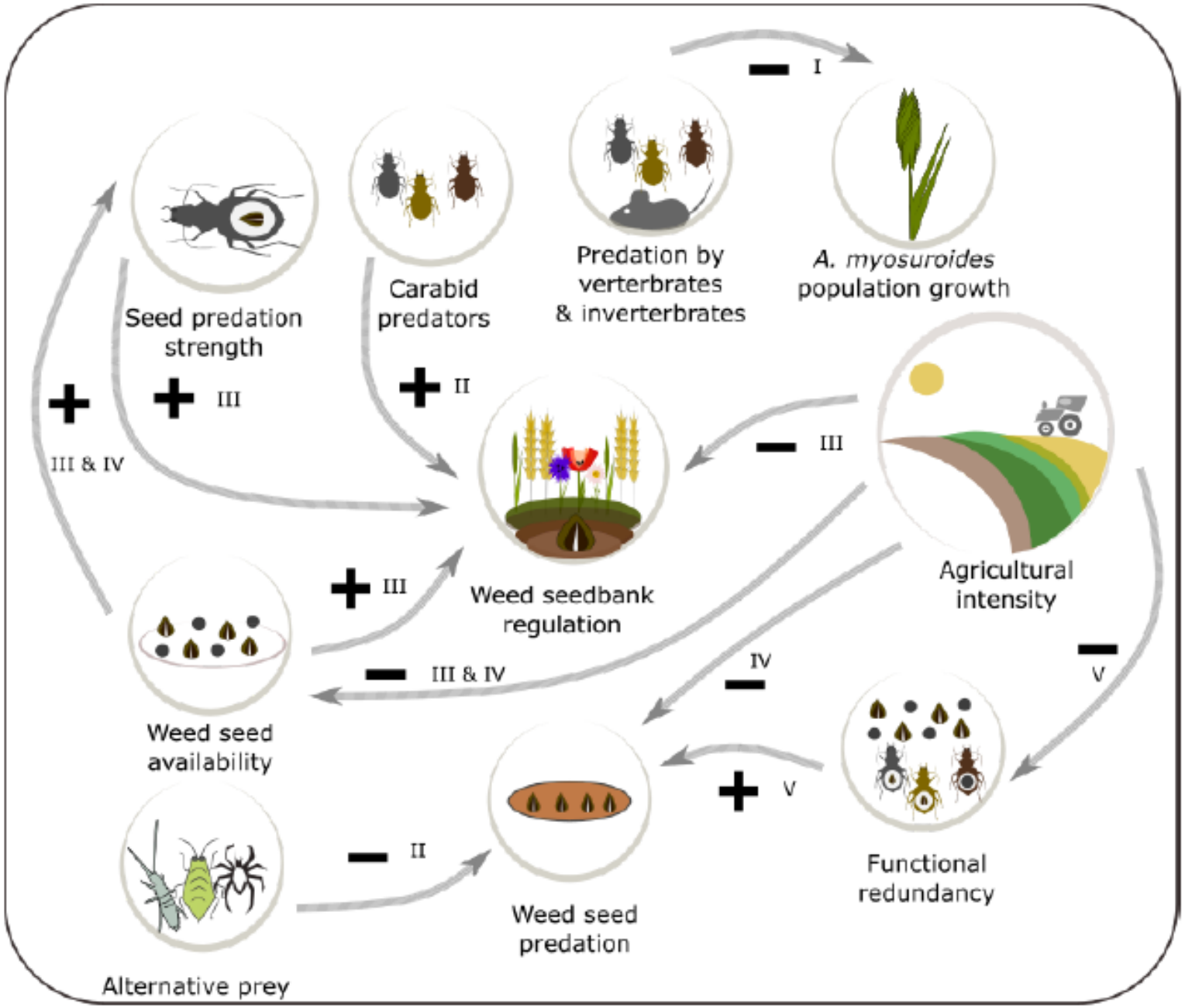
Bötzel et al. (manuscript)

## Intercropping with service crops

Multi-criteria assessments including mobile elements.

Field experiments are often replaced with on-farm studies, e.g. pairwise design

Bötzel et al. (submitted manuscript) Photo: Göran Bergkvist




# Trophic interactions

## Short and long term effects

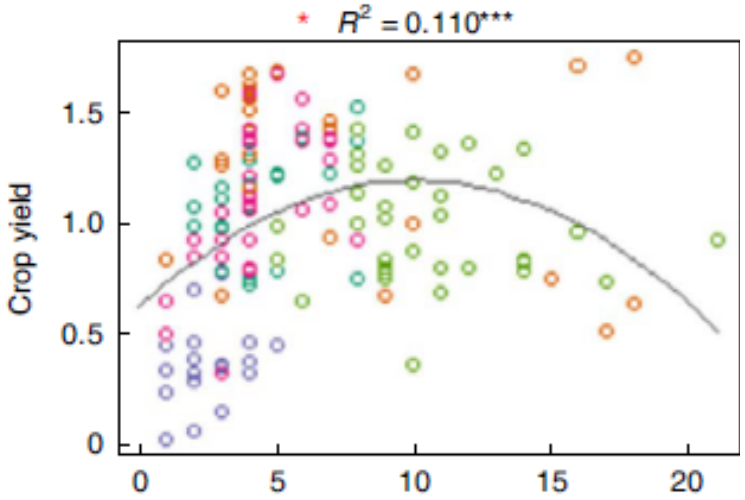
Daouti (2021). *Weed seed predation : a promising ecosystem service in agriculture.* Diss. Acta Universitatis Agriculturae Sueciae, 1652-6880

Long-term effects of rotations:

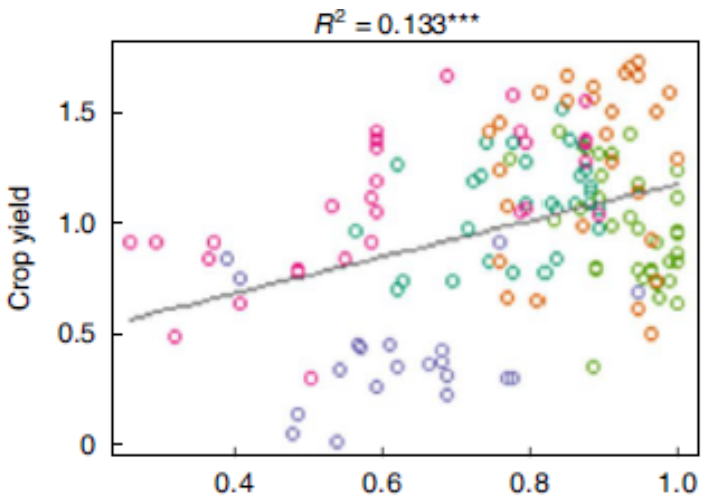
**Crop cover and management intensity more important for yield than crop diversity, when crop diversity is enough**

(155 fields across Europe).

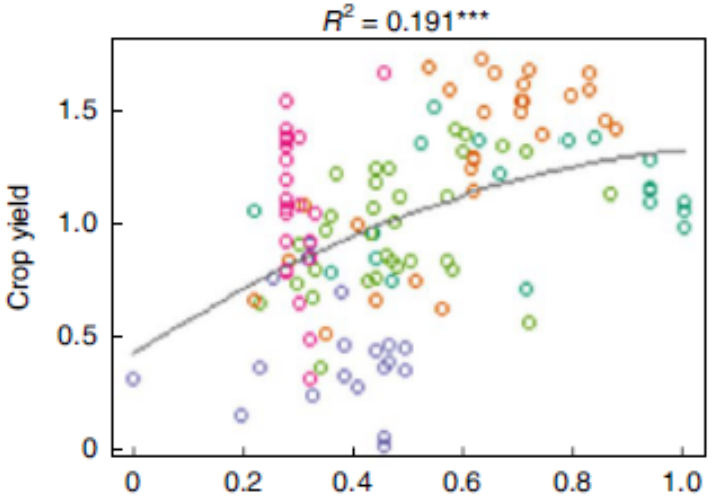
Long term experiments or on farm studies?




Crop diversity

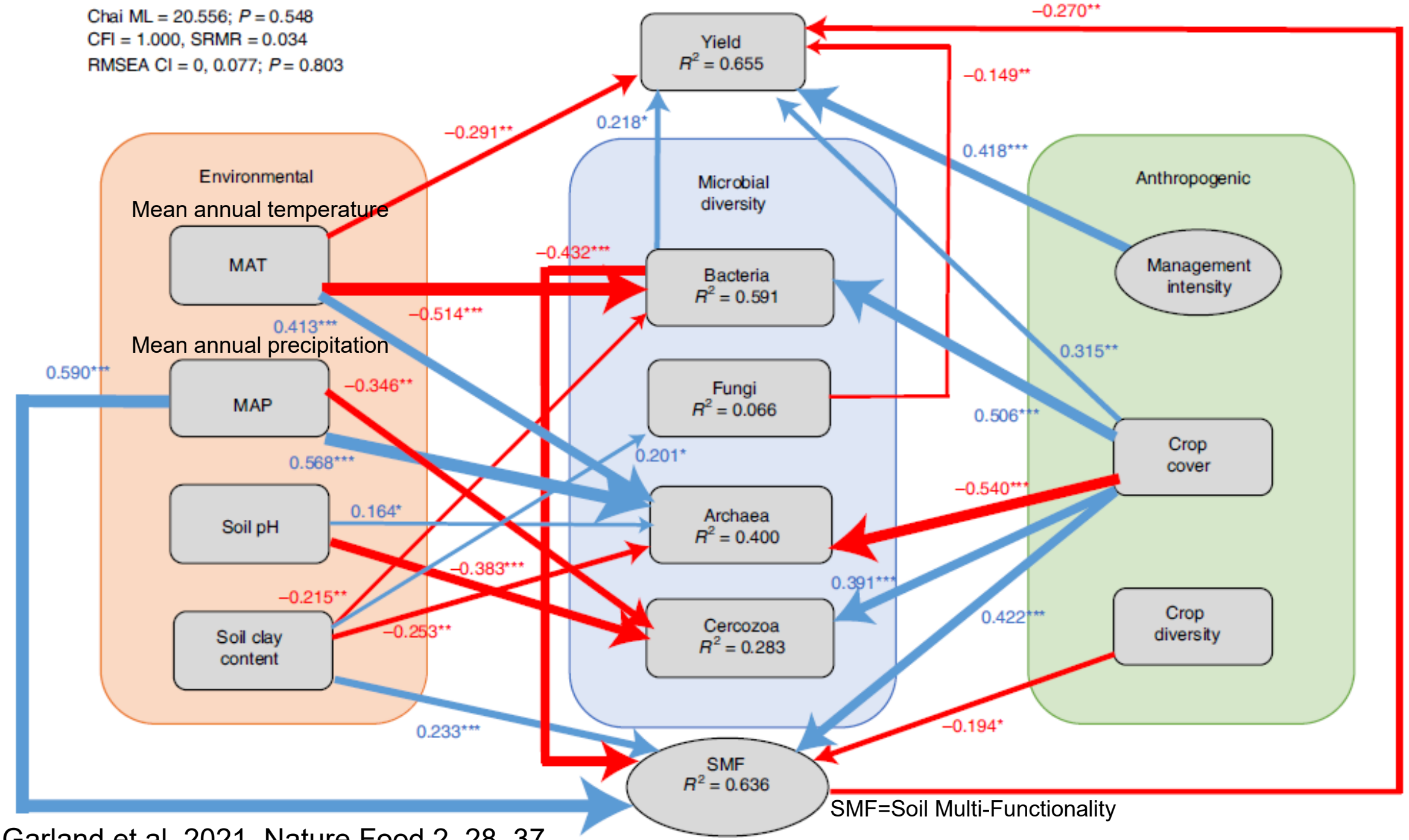



Crop cover




Management intensity

Garland et al. (2021) Crop cover is more important than rotational diversity for soil multifunctionality and cereal yields in European cropping systems. Nature Food 2, 28–37.. doi:10.1038/s43016-020-00210-8




Garland et al. 2021. Nature Food 2, 28–37.

# Long term experiments as platforms for research

- Replicated environments created at one or multiple sites, lab always in place
- Long term effects of treatment and effects of weather depending on created environments (treatments)

But

- Expensive and difficult to manage
- Interactions between plots
- Few environments
- Drift away from common practice
- Site might not have the urgent problem

## Some ideas regarding “new” long term experiments

# Winter or spring crops in a warmer climate? (R4-0009, start 2010)

- Sufficiently replicated, four replicates – 48 plots
- Study crop – break crop instead of fully phased
- Treatments consist of principles to follow rather than specific comparisons
- Contains a mix of C3 and C4 plants

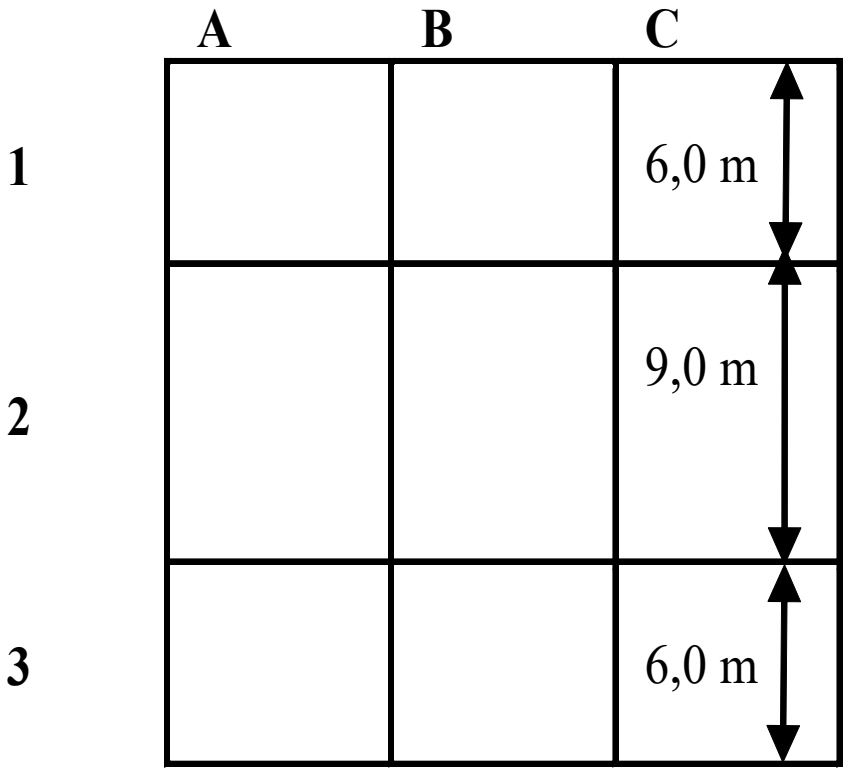
| CS 1 | CS 2 | CS 3 | CS 4 | CS 5 | CS 6 |
|---|---|---|---|---|---|
| Winter wheat | Maize | Winter wheat | Maize | Barley u.s. | Barley u.s. |
| Winter wheat | Maize | Linseed | Linseed | Clover /grass | Grass |
| Winter wheat | Maize | Winter wheat | Maize | Clover /grass | Grass |
| Winter wheat | Maize | Winter rape | Spring rape | Winter wheat | Grass |
| Winter wheat | Maize | Winter wheat | Maize | Field bean | Grass |
| Winter wheat | Maize | Pea | Field bean | Maize | Grass |

- CS3 and CS4 ploughed and non-inversion tillage.

Bergkvist et al. (2011) Aspects of Applied Biology 113, 61 – 66.

# Innovations

- Allows adaptation of management when learning
- Plot size 20 x 21 m: 420 $m^2$ enables satellite images, splitting of individual plots and smaller zones for short–term experiments



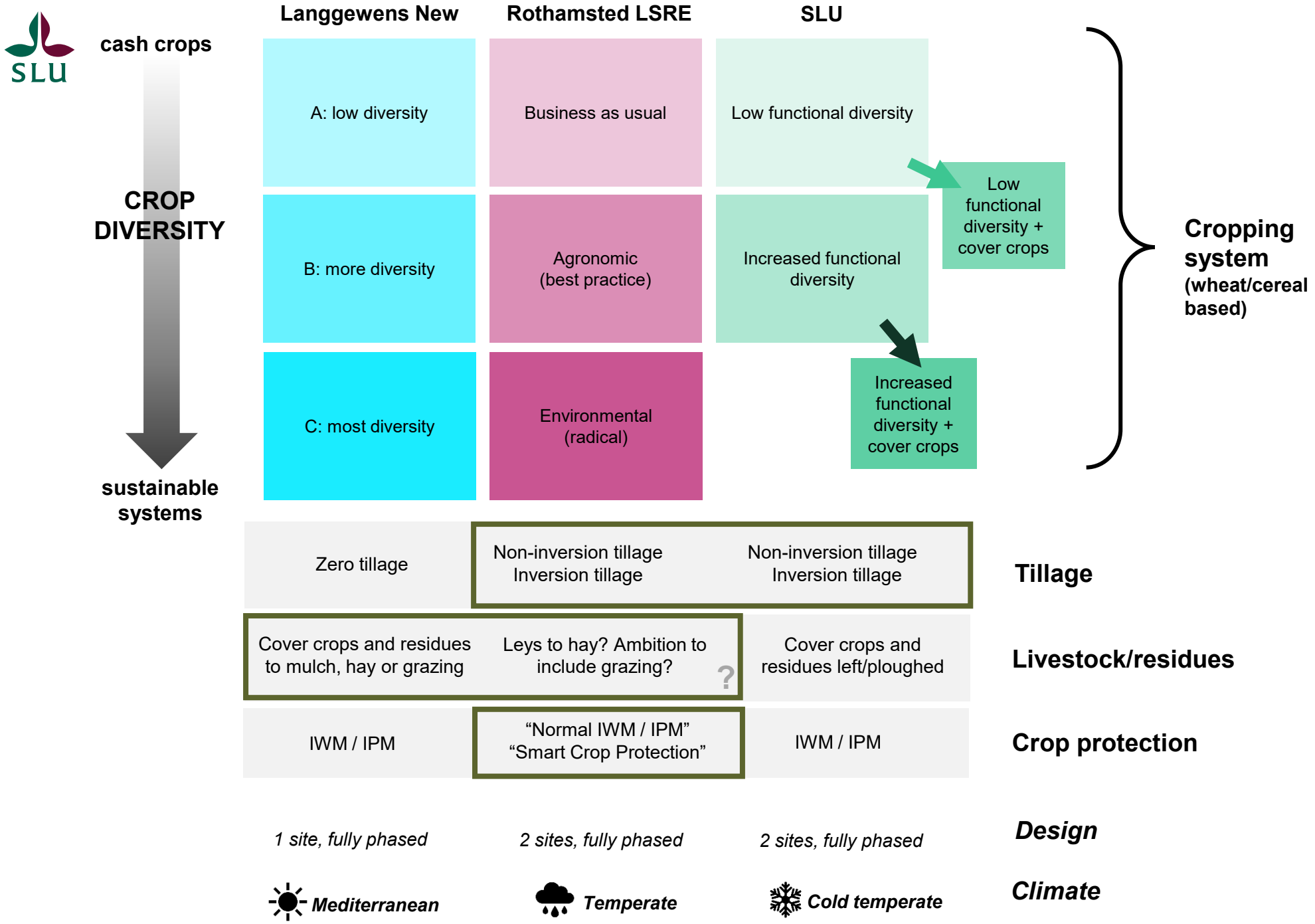

# Preparing for the future: sustainable cropping systems without glyphosate – start 2020

Alexander Menegat

Marcus Willert

Thomas Keller

Göran Bergkvist


Langgewens New
Rothamsted LSRE
SLU
cash crops
CROP DIVERSITY
sustainable systems
A: low diversity
Business as usual
Low functional diversity
B: more diversity
Agronomic (best practice)
Increased functional diversity
C: most diversity
Environmental (radical)
Low functional diversity + cover crops
Increased functional diversity + cover crops
Cropping system (wheat/cereal based)
Zero tillage
Non-inversion tillage
Inversion tillage
Non-inversion tillage
Inversion tillage
Tillage
Cover crops and residues to mulch, hay or grazing
Leys to hay? Ambition to include grazing?
?
Cover crops and residues left/ploughed
Livestock/residues
IWM / IPM
"Normal IWM / IPM"
"Smart Crop Protection"
IWM / IPM
Crop protection
1 site, fully phased
2 sites, fully phased
2 sites, fully phased
Design
Mediterranean
Temperate
Cold temperate
Climate

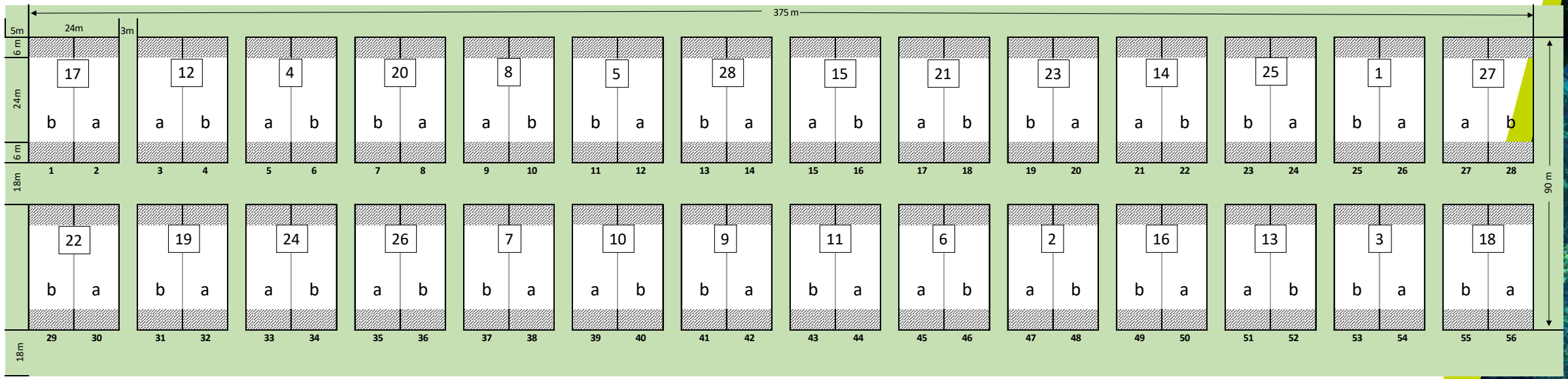
All crops all years, randomised with two replicates

Innovations

- International collaboration gives more environments and knowledge sharing
- Prioritise large plots and environments before replicates
- Several disciplines involved. Evaluation of multiple parameters.
- Stakeholder involvement in management – dynamic management

Challenges

Interpretation, still quite small plots, effects of protection areas, expensive



# Conclusions - needs to be explored in field experiments

1. Effects and mechanisms for ecological management of weeds, pests and diseases - preventive measures or combining preventive with curative direct control.
2. Long term and environmental effects of preventing, controlling and their combination.
3. Sustainability (multiple criteria) assessments of cropping systems