Agri culture 4.0

NOcsPS

without Chemical-Synthetic Plant Protection

UNIVERSITY OF HOHENHEIM

JKI Julius Kühn-Institut

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Pesticide Free Cropping Systems - Game Changer or Slow Sellers?

NOcsPS: Development and holistic analyses of a cropping system without chemical-synthetic plant protection products but with optimized use of mineral fertilizers

SEARCA Agriculture and Development Seminar Series, Drilon Hall, Los Baños, Laguna 12/10/2024

Enno Bahrs, University of Hohenheim

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Green Deal of EU

Current Farming Concepts – either or…

Basic concepts

Conventional ⟷ **Organic**

Maxim:

Maximization of yield

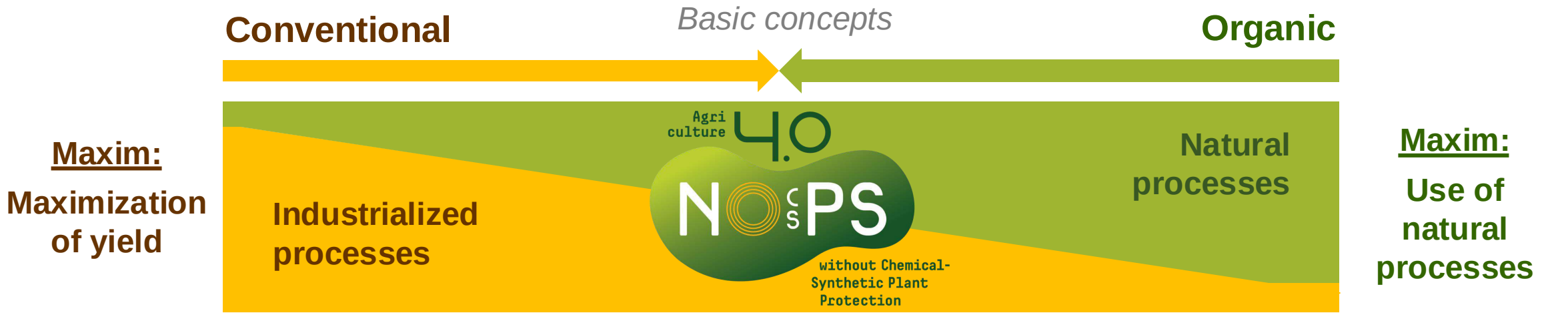
Maxim:

Use of natural processes

Industrialized Process Control	Natural Process Control
- monotone crop rotations	- diverse crop rotations
- low degree of heterogeneity in agricultural landscape	- high degree of heterogeneity in agricultural landscape
- high-yield varieties	- site-adapted, resistant varieties
- high external inputs	- low external inputs
- open cycles	- towards closed cycles
- high capital intensity	- low capital intensity
- low labor intensity	- high labor intensity
- high degree of mechanization	- low degree of mechanization
- high degree of specialization	- low degree of specialization
- high vertical integration	- covers a large part of the value chain
- comprehensive control of agricultural production processes	- higher use of natural regulatory processes for agricultural production

Source: Zimmermann et al., 2021. https://doi.org/10.3390/agronomy11091710

Farming Concepts – the Fifty Shades of Green



Source: Zimmermann et al., 2021. https://doi.org/10.3390/agronomy11091710

- ✓ No use of CSPs (pesticide free)
- ✓ Moderate use of mineral fertilizer
- ✓ Use of new technologies and agro-ecological measures

Why do we need „pesticide free“ farming concepts/cropping systems?

- ➢ Registration restrictions for future and fewer active ingredients for CSPs
- ➢ Securing the quantitative supply of food
- ➢ Residues of CSPs viewed critically by society

Challenges for pesticide free farming concepts / cropping systems

- **Yield depression or yield losses**
  - Diseases
  - Pest infestation
  - Weeds
- **Economic risk and Marketing**
  - Quantity
  - Quality
- **....**

Sustainability aspects

Objective: Improvement for ecosystem services of agricultural landscapes

- Production of healthy food and high **supply performance**
- Preservation and promotion of **biodiversity**
- Increasing **sustainability** with a contribution to climate protection
- **Consumer acceptance**

SUSTAINABLE DEVELOPMENT GOALS

What characteristics must a pesticide free cropping system have in order to achieve the stated objective and goals?

Main characteristics of NOcsPS cropping systems

Agro-ecological measures

- Diverse crop rotations
- Disease-resistant varieties
- Optimized sowing patterns
- Landscape elements

Promotion of resilience, yield stability and resource protection

Environmentally friendly use of nutrients and bio-based crop protection products

- Mineral micro- and macro-nutrients
- Bioeffectors (bacteria, algae)
- Beneficial organisms

Promotion of plant growth and plant health

Smart Farming Technologies

- Monitoring of plant growth and plant health
- Application of seeds, nutrients, beneficial organisms and bio-based pesticides
- Weed control (camera-controlled, automated weed hoe/harrow)

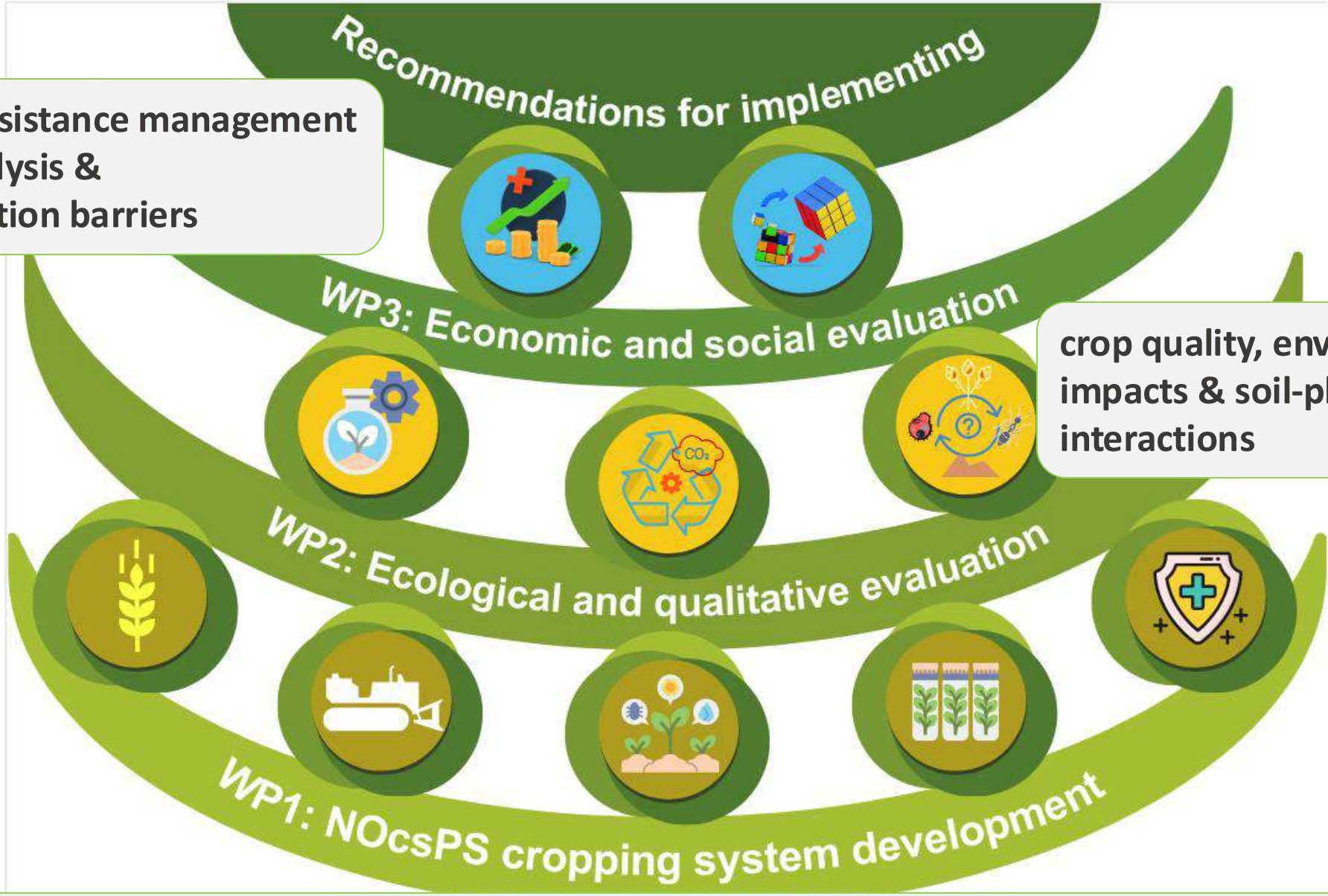
Increasing resource efficiency

Project Partners - quite interdisciplinary…

CP1	Experimental Station UHOH & JKI
CP2	Weed Science
CP3	Agronomy
CP4	Technology in Crop Production
CP5	Soil Biology
CP6	Fertilization and Soil Matter Dynamics
CP7	Nutritional Crop Physiology
CP8	Biogeophysics
CP9	Crop Biodiversity and Breeding Informatics
CP10	Phytopathology
CP11	Strategies and Technology Assessment
CP12	Strategies and Technology Assessment
CP13	Landscape and Plant Ecology
CP14	Quality of Plant Products
CP15	Biobased Resources in the Bioeconomy
CP16	Farm Management
CP17	Theory and Resource Economics
CP18	Societal Transition and Agriculture
CP19	Marketing for Food and Agricultural Products

Work packages and subprojects

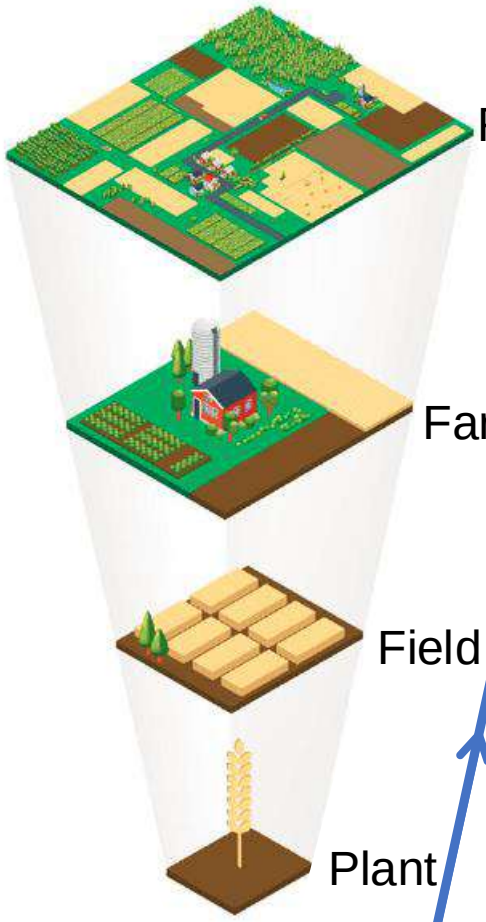
economic resistance management and risk analysis & implementation barriers



crop quality, environmental impacts & soil-plant-pathogen interactions

crop production, smart farming techniques, plant nutrition and soil ecology, breeding & plant protection

Research at all Scales



Region

Conversion of the Cultivation System

Farm

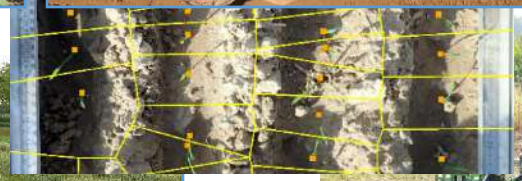
Farm Analyses Surveys

Field

System- and Exact-Trials

Plant

Lab Analyses and Greenhouse Experiments



Cropping Systems and Crop Rotations of the System Trials

Cropping System	Conventional (CI)	Conventional (CII)	NOcsPS I	NOcsPS II	NOcsPS III	NOcsPS IV	Organic
Sites	UHOH	UHOH / JKI	UHOH / JKI		UHOH		UHOH / JKI
Crop rotations	Winter wheat	Winter wheat I	Winter wheat I	Winter wheat I	Winter wheat I	Winter wheat I	Winter wheat I
	Maize	Maize	Maize	Maize	Maize	Maize	Maize
	Soybean	W-Triticale / W-Rye	W-Triticale / W-Rye	W-Triticale / W-Rye	W-Triticale	W-Triticale	W-Triticale / W-Rye
		Soybean / Pea	Soybean / Pea	Soybean / Pea	Soybean	Soybean	Soybean / Pea
		Winter wheat II	Winter wheat II	Winter wheat II	Winter wheat II	Winter wheat II	Winter wheat II
		Spring barley	Spring barley	Spring barley	Spring barley	**Ryegrass**	**Clover grass**

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NOcsPS - Results

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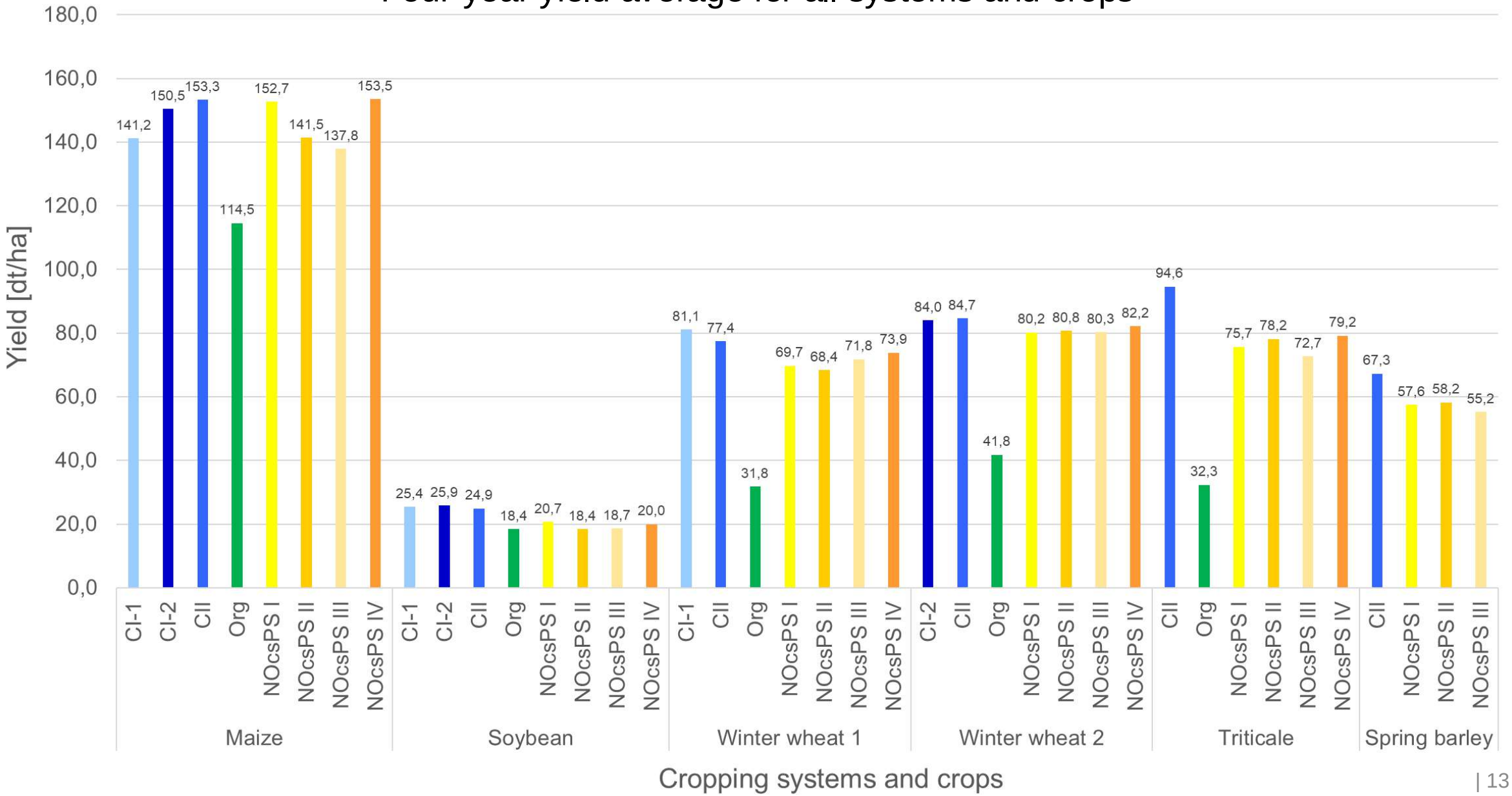
Crop yields UHOH 2020-2023

Four-year yield average for all systems and crops



How to make these systems comparable with regard to their sustainability impact?

- **A common denominator is needed to compare the yields of different fruits and systems – the Grain Unit (GU)**
- **GU as a uniform benchmark to standardize and compare the production performance and feed value of different agricultural products**, which is important both in LCA and in agricultural business management.
- The grain unit (GU) is used as a common denominator for gross land production as well as for food production and net food production. It allows the individual products to be combined into a total value. The grain unit is an **indicator that reflects the energy supply capacity of a product in relation to the calculated energy supply capacity of barley**, depending on the structure of use of the agricultural product in feeding. The animal products are not assessed according to their own net energy content, but according to the net energy content of the feed that is required on average for their production.

Grain equivalent unit (GE) for the crop rotation (mean 2020-2023)

Cropping system	Hohenheim (BW) GE/ha	Hohenheim (BW) GE in comparison to Conv. II. [%]	Dahnsdorf (BB) GE/ha	Dahnsdorf (BB) GE in comparison to Conv. II [%]
Conventional II	**411**	**100**	**371**	**100**
NOcsPS I	356	87	288	77
NOcsPS II	351	85	256	69
NOcsPS III	344	84	-	-
NOcsPS IV	351	85	-	-
Organic	206	50	276	74

Source: Hermann, W., Schwarz, J., 2023. Yield data University of Hohenheim and Julius Kühn-Institut 2020 to 2023.

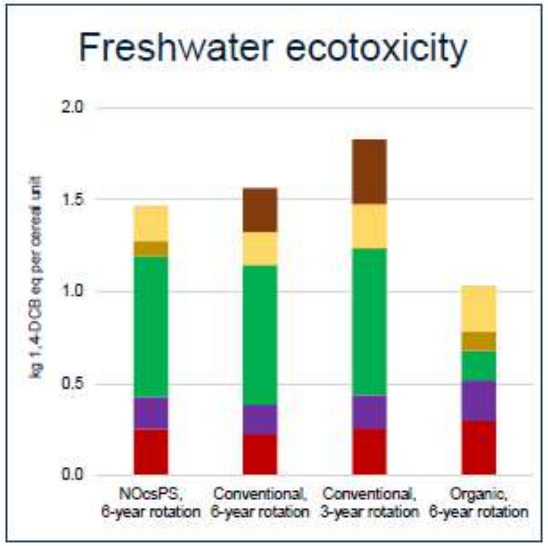
Interim Conclusion (Hypothesis)

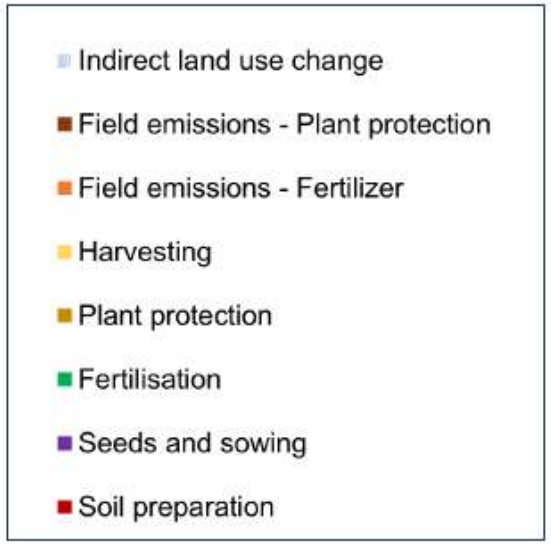
- In NOcsPS cropping systems, reduced yields compared to conventional systems depend on the location and the position of the crop in the crop rotation. **Yield losses in NOcsPS cropping systems were so far lower than expected (especially in Hohenheim)**

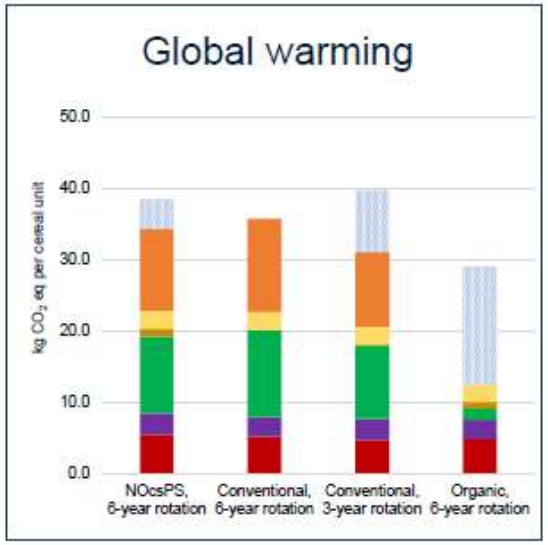
- **But what about the sustainability effects?**

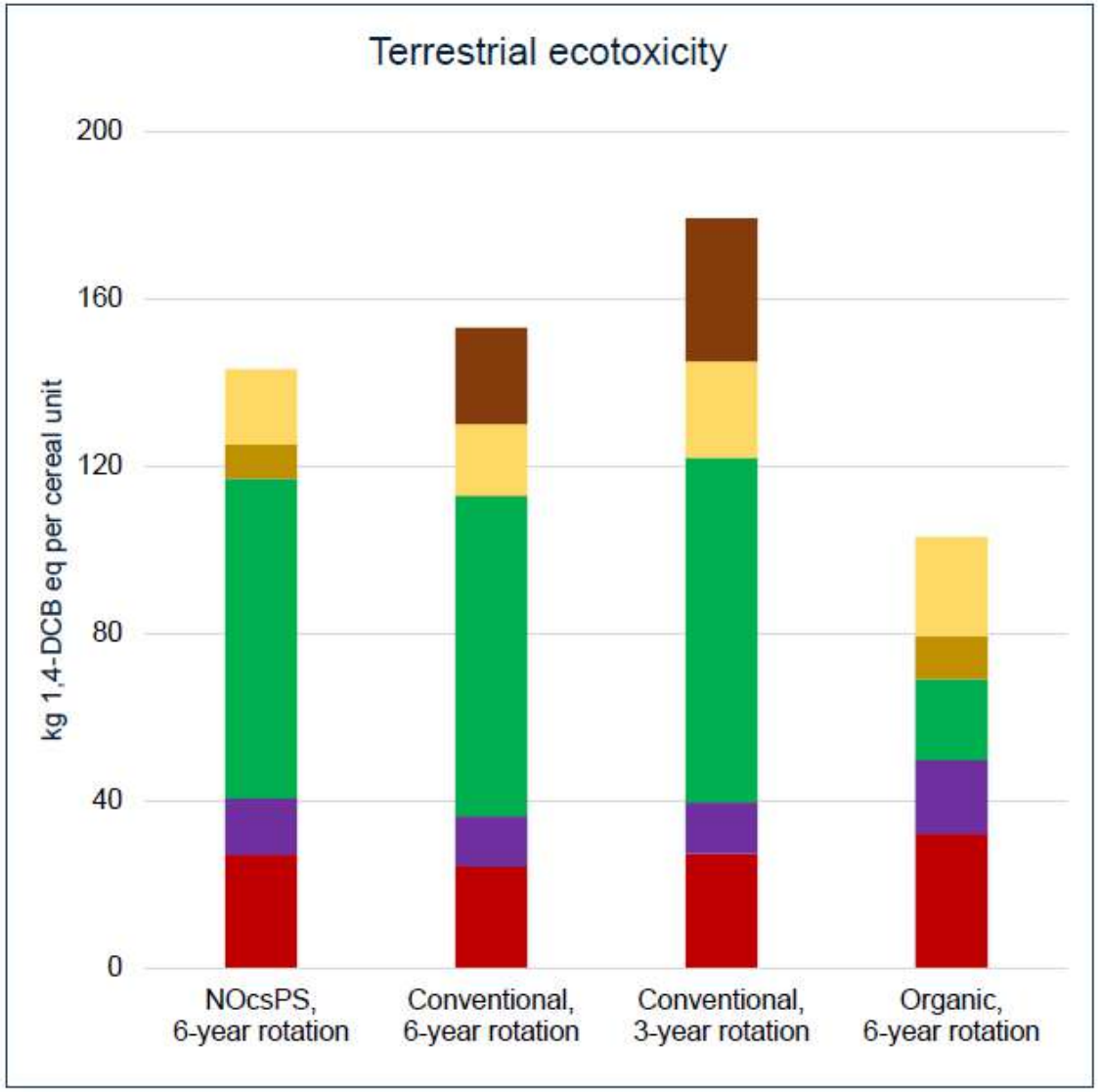
Preliminary Life Cycle Impact Assessment results (ReCiPe2016) and Contribution Analysis of NOcsPS, Conventional and Organic Crop Rotations with four-year Yield Average for all Systems and Crops, Location: University of Hohenheim

Cropping system	Yield (cereal units/ha*6a)
NOcsPS (6-year rotation)	367
Conventional (6-year rotation)	415
Conventional (3-year rotation)	316
Organic (6-year rotation)	227









There are many more Indicators to be analysed…

Environmental Impacts (ReCiPe 2016)

- Climate Change
- Stratospheric ozone depletion
- Ionizing radiation
- Fine particulate matter formation
- Photochemical ozone formation
- Terrestrial acidification
- Freshwater eutrophication
- Marine eutrophication
- Toxicity
- Water use
- Land use
- Mineral resource scarcity
- Fossil resource scarcity

With regard to the Preliminary LCA results: What is the advantage of “pesticide free”?

- Pesticide free has **lower toxicity categories than conventional farming** and **requires less land per unit of product than organic farming**. Both impact areas, land use and toxicity, are **“proxy indicators” for biodiversity loss**.

- **Pesticide-free is a very convincing story**. The system is **much easier to explain** than “**less pesticide**” an **eco-certified system**, which could involve **a lot of rules**.

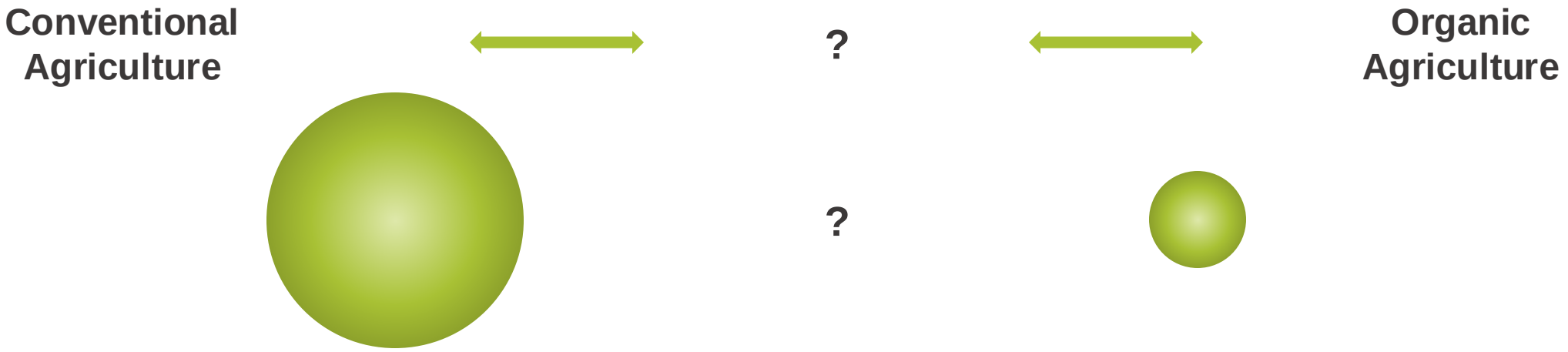
Marketing challenges

Objective

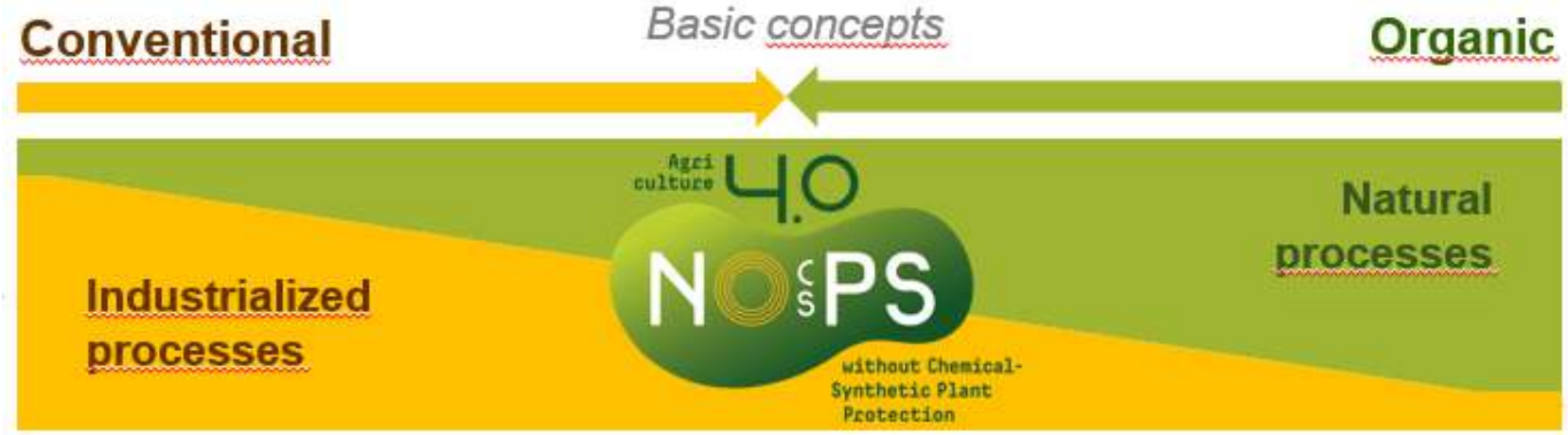
Marketing Options for Pesticide Free Cultivation Systems in the Food Chain

Are there any Opportunities for Pesticide Free Products on the Market?

Key question



Can a “pesticide free form” of agriculture be established on the market?



Source: Zimmermann et al., 2021. https://doi.org/10.3390/agronomy11091710

Results of consumer studies on hypothetical willingness to pay

High hypothetical willingness to pay

Product	Anchor prices: Convent. Product	Anchor prices: Organic-Product	**Informations-Treatment** (Informationen zum NOcsPS-Anbau [ja/nein])	**Ø Willingness to pay**	**Willingness to pay in multiples vs. conv. Product**
Soy drink (1 Liter) *	0,99 €	1,49 €	Without information	1,37 €	38,4 %
			information	1,49 €	50,5 %
Tofu (natural, 200 grams) *	0,89 €	1,39 €	Without information	1,30 €	46,1 %
			information	1,46 €	64,0 %
Wheat roll	0,35 €	0,65 €	Without information	0,56 €	60,0 %
			information	0,60 €	71,4 %
Wheat flour (1000 grams) *	0,79 €	1,39 €	Without information	1,27 €	60,8 %
			information	1,42 €	79,7 %
Lettuce	0,79 €	1,99 €	Without information	1,53 €	93,7 %
			information	1,66 €	110,1 %
Beer (0,5 Liter)	0,59 €	1,39 €	Without information	1,18 €	100,0 %
			information	1,26 €	113,6 %

See also Nitzko et al., 2024, https://doi.org/10.1016/j.farsys.2023.100059

Results of the Food-Chain-Analysis

Advantages	Disadvantages
• Marketing-related advantages • Development of an innovative product group • Positive effects on corporate image/reputation • Internal company benefits (e.g. cost savings for residue analyses) • Fulfillment of consumer demand for more natural foods • Contribution to environmental protection and nature conservation	• Higher prices compared to conventional raw materials • Availability may be problematic (risk to security of supply) • Consumer communication challenging • No established labels available • Consumer acceptance of higher prices questionable • Consumer product differentiation (organic vs. pesticide free vs. conventional) questionable • Disadvantages due to use of mineral fertilizers (analyses required) • Risk of quality defects due to lack of pesticides • Risk of increased contamination of raw materials (mycotoxins etc.)

Classification of Pesticide Free from the perspective of food manufacturers and retailers currently still unclear:

- Relevance of the pesticide issue is recognized
- But no clear idea of how such a segment could be established
- Ultimately an expression of **a lack of a marketing strategy idea for the future** of a recognizable segment
- This segment would currently be more important than ever in **view of the price/inflation crisis on food market**

Name for a new cultivation system? Not easy...

Categories	Percentage frequency
Designations with reference to **the waiver of csPSM**	12.7%
Designation as a **hybrid cultivation system**	5.7%
Designation as an **alternative form** of agriculture	5.7%
Designations with **reference to mineral fertilization**	4.9%
Designations **related to the future/innovation**	4.7%
Designations **related to sustainability**	3.1%
…	

How to name it?

- Reference to nature/naturalness would be appropriate from a marketing perspective - but legally problematic
- Reference to organic farming is excluded for legal reasons.
- Reference to the renunciation of chemical-synth. pesticides such as “pesticide-free”: negative connotation of the term pesticide and lack of positive associations

Conclusion and Outlook

- In NOcsPS cropping systems, reduced yields compared to conventional systems depend on the location and the position of the crop in the crop rotation. **Yield losses in NOcsPS cropping systems were so far lower than expected.**
- Pesticide Free should have a **positive effect on environmental protection**
- A prerequisite for the successful and sustainable application of NOcsPS cultivation systems **are effective non-chemical plant protection and fertilization measures using modern technologies and suitable site-adapted crops and crop rotations**
- The **project has to be continued** to ensure long-term effects on ecosystem services, economic aspects and a reliable assessment of sustainability
- Second phase starts in 2025 (prospective four years)

Exemplary follow-up Hypotheses and Requirements

Are NOcsPS cultivation systems more suitable for better sites with good water supply and nitrogen replenishment than for sites with poorer site conditions?

Pesticide Free cultivation systems have effects on the self-sufficiency of arable crops.

Valid results and a market launch require long (funding) periods. A few years of experience can only illustrate trends.

“Pesticide Free” cultivation systems have opportunities on the market. Perceived risks on the part of agriculture, trade and politics could be overcome through a systems approach.

How pesticide-free systems can be implemented in practice

Scope of the area commitment

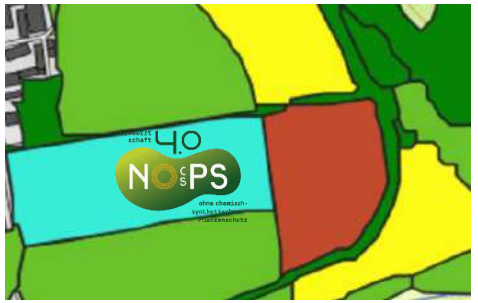
Total Operating Farm Area

Partial Area

Whole Farm

Flexible in terms for culture and space (German Funding Program)

Parcel-specific



Time commitment

Annual

Perennial

Science communication / public relations

Agricultural robot “Phoenix” from NOcsPS

on TV and at the Federal Government's digital summit in December 2022 with Chancellor Olaf Scholz

Federal Minister of Agriculture Cem Özdemir

in Hohenheim with NOcsPS

Prof. Ralf Vögele
(Deputy NOcsPS Coordinator)

In the state parliament of BW

Prime Minister of BW Kretschmann & State Minister of Science in BW Olschowski

in Hohenheim with NOcsPS

Our YouTube-Channel

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See also: https://nocsps.uni-hohenheim.de/en/english

Pesticide Free Systems useful for the Philippines?

- Climate Conditions?
- Education?
- Traditions?
- Conditions of the value chains?
- Welfare and willingness to pay?
- …

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