CropBooster-P

"Preparatory action to Boost Global Crop Yield for Food & Nutrition Security and fueling a Bioeconomy"

Type of action: CSA
Coordination and Support Action (CSA) aims to build the foundations and framework for a pan-European initiative

***WP4** "Strengthening international cooperation"*

Norbert Rolland
Günter Strittmatter
Peter Westhoff

Horizon 2020
Call: H2020-SFS-2018-2020
(Sustainable Food Security)
Topic: LC-SFS-15-2018

European Commission | Horizon 2020 European Union funding for Research & Innovation

The challenges of CropBooster-P WP4

Task 4.1. Map the existing research communities using existing formal and informal EU networks

- Research communities mostly coming from academic organisations (Research Institutes and Universities).
- Create a network model of existing or lacking interactions from the mapping, and their distribution within Europe.
- Applied Research communities (Private companies, R&D services of Cooperatives, Technical Institutes, etc.).
- Select people from all partners at European level to assemble an expert panel. MS15

Deliverable 4.1

Task 4.2. Link research communities identified during task 4.1 by organizing joint meetings betweeen plant scientists

- Organize networking activities with the different Research communities to identify experts for (link with WP1).
- Organize a joint meeting between European scientists from different disciplines and ongoing research programs. MS16
- Assemble an expert panel to review strategies (see task 4.3)

Task 4.3. Reviewing scientific and technical strategies on the scientific basis of existing and future tools and approaches

- Literature research and expert assessment to discuss and resume available strategies, options, technologies and present limitations to improve yield, quality and sustainability in different crop species. Report on state of the art, knowledge gaps, trans-disciplinary frontiers, novel technologies and knowledge synthesis needs. MS17

Deliverable 4.2

- Writing of scientific reviews to propose the best scientific options to further improve the selected crops in future agriculture. Joint review articles and research visions submitted for open access publication (work to be done in coordination with WP5).

Deliverable 5.7

Work package 4: International Cooperation [Months: 1-36->42]
INRAE, WR, VIB, WU, CNR, EPSO, UDUS, UNOTT, CNRS, UCPH, ULANC, USAMV CLUJ, ESA, ACTA

Task 4.1. This task aims to map the existing research communities using existing formal and informal EU networks (M1-M18->M24).

Task leader: **UDUS**; other partners: WR, VIB, CNR, EPSO, UNOTT, CNRS, UCPH, INRA, ULANC, USAMV, ESA, SORBONNE, ARVALIS

- Research communities (physiologists, geneticists, breeders, modellers, agronomists, socio-economists, pathologists, etc…) who are mostly coming from academic organisations (Research Institutes and Universities).
- Create a network model of existing or lacking interactions from the mapping of national or international communities and projects, and their distribution within Europe.
- Applied Research communities (Private companies, R&D services of Cooperatives, Technical Institutes, networks of Experimental Stations etc.).
- Selecting people from all partners at European level to assemble an expert panel.

Map of the existing research communities

The end-product, the Network Map of Research Networks (Deliverable 4.1), gives a thorough and comprehensive overview of scientific cooperation in the field of plant research in Europe.

https://www.cropbooster-p.eu/data/upload/files/d4-1-final-report-17-12-2020.pdf
https://www.cropbooster-p.eu/the-project/project-results.html

Aim of the first step:

●Research communities (physiologists, geneticists, breeders, modellers, agronomists, socio-economists, pathologists, etc…) who are mostly coming from academic organisations (Research Institutes and Universities).

The aim of this study was to **identify the main European institutions** which publish in the fields corresponding to the different traits identified during WP1 as being able to improve yield.

Method: Screening of the scientific production (**WoS**) during five years **(2015-2019)** using key terms linked to traits (Yield, Sustainability, Nutritional quality) selected during the WP1 and WP2.

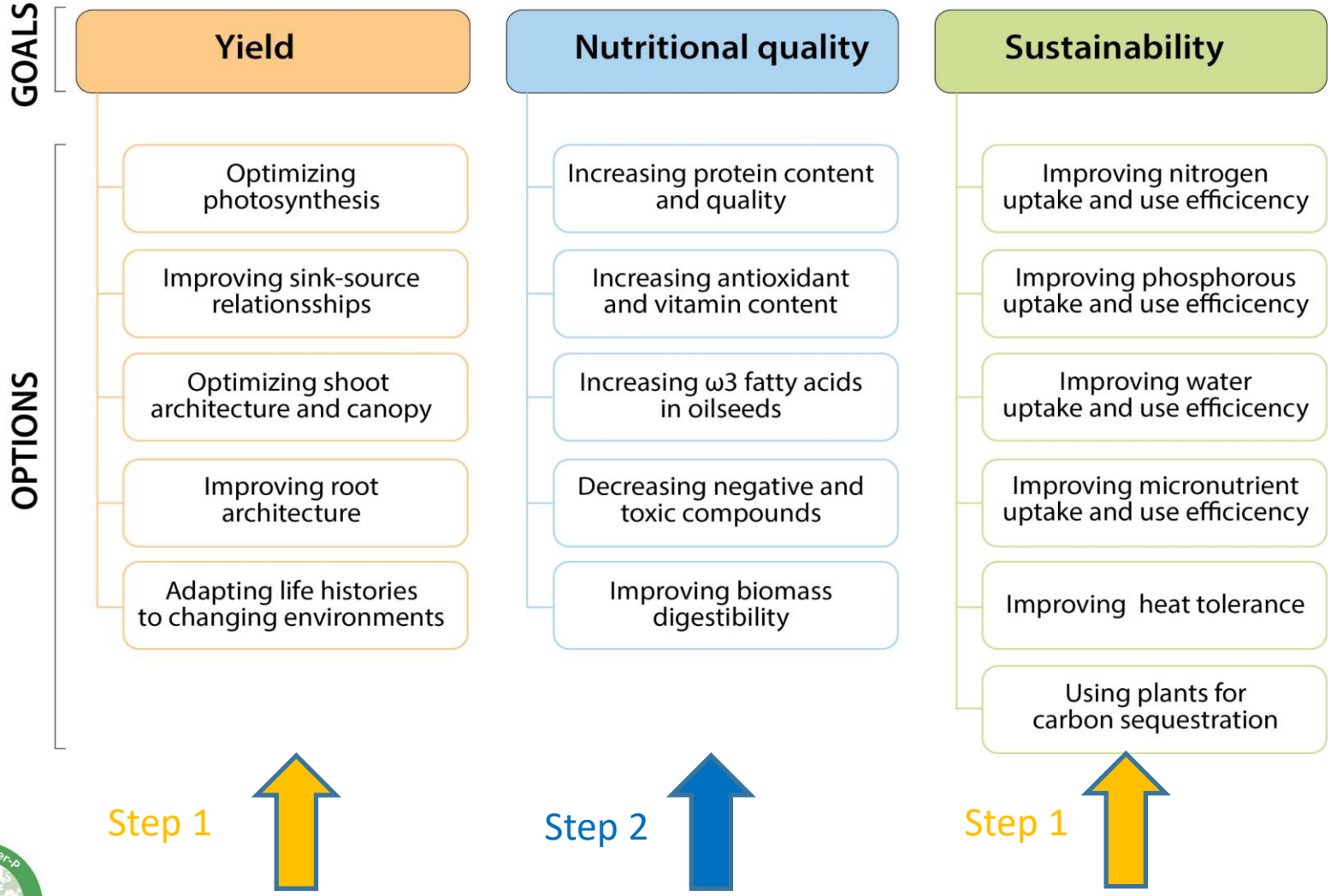
A **total of 14,053 publications** were collected and analyzed for **"yield" and "sustainability" (step 1) + > 10,000 publications** for **"nutritional quality" (step 2)**.

Dominique Fournier, INRAE, Montpellier, France
Jacqueline Martin-Laffon, CNRS, Grenoble, France
Bertrand Muller, INRAE, Montpellier, France
Philippe Nacry, INRAE, Montpellier, France
Norbert Rolland, INRAE/CNRS, Grenoble, France

Selected traits for the literature screening

(According to WP1 and WP2)

Step 1: "Yield" and "sustainability"

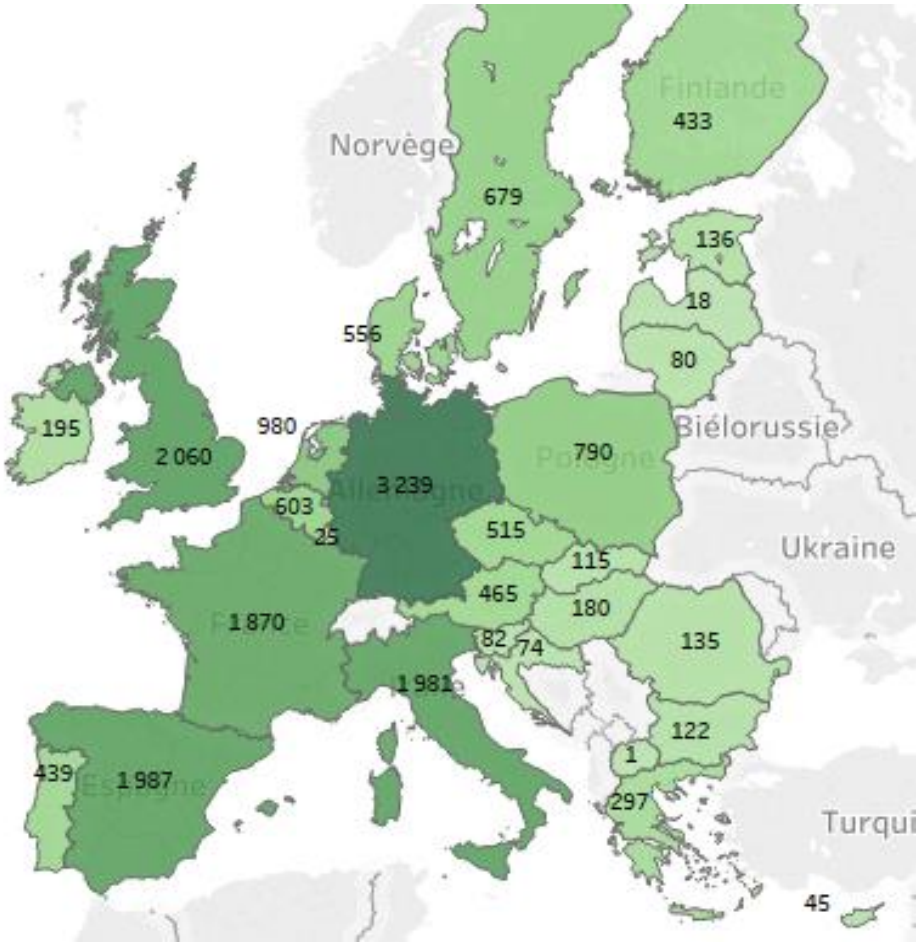


Part of UE28 in the publications collected and analyzed

Note that, in these research fields, publications signed by EU28 scientists represent between 27% and 47% of global scientific production.

Traits identified by experts in WP1	Publications UE28	Publications World	Publications UE28 / World
Nutrient-uptake	3 070	8 822	35%
Secondary-metabolism	3 040	8 880	34%
Growth-rate	1 960	7 119	28%
Nutrient-metabolism-transport	1 655	5 585	30%
Biochemistry-carbon-assimilation	1 372	3 491	39%
water-use-efficiency	1 226	4 371	28%
Nutrient-use-efficiency	824	3 001	27%
Photochemistry	669	1 543	43%
Photoprotection	556	1 288	43%
Shoot-architecture	492	1 454	34%
Primary-metabolism	455	973	47%
Source-Sink Balance	414	1 209	34%
Leaf-anatomy	263	885	30%
Source Web of Science Clarivate Analytics – 2015-2019 – Treatment INRAE/CNRS 2020 - Article , Review, Proceeding Papers or Letters			

Origin of the 14,053 publications at EU28 scale

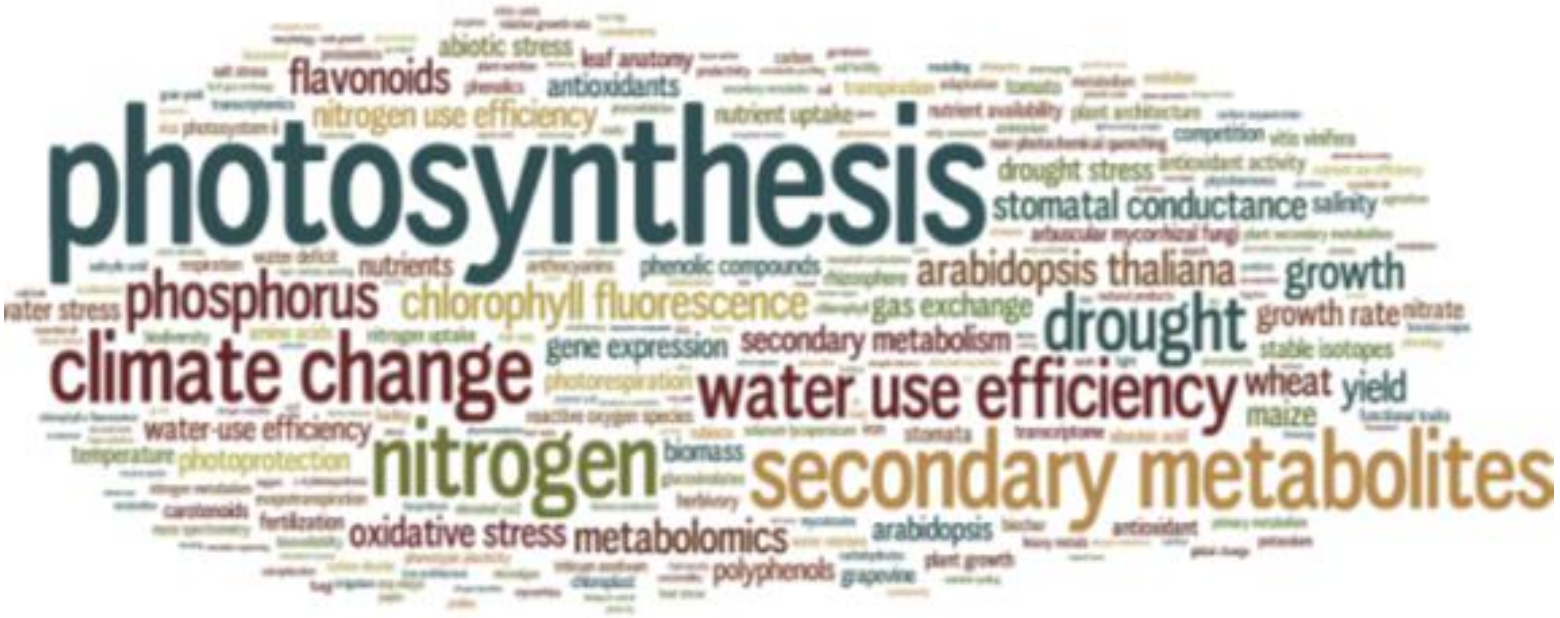


Analysis of publications Web of Science™ 2015-2019

Author Keywords

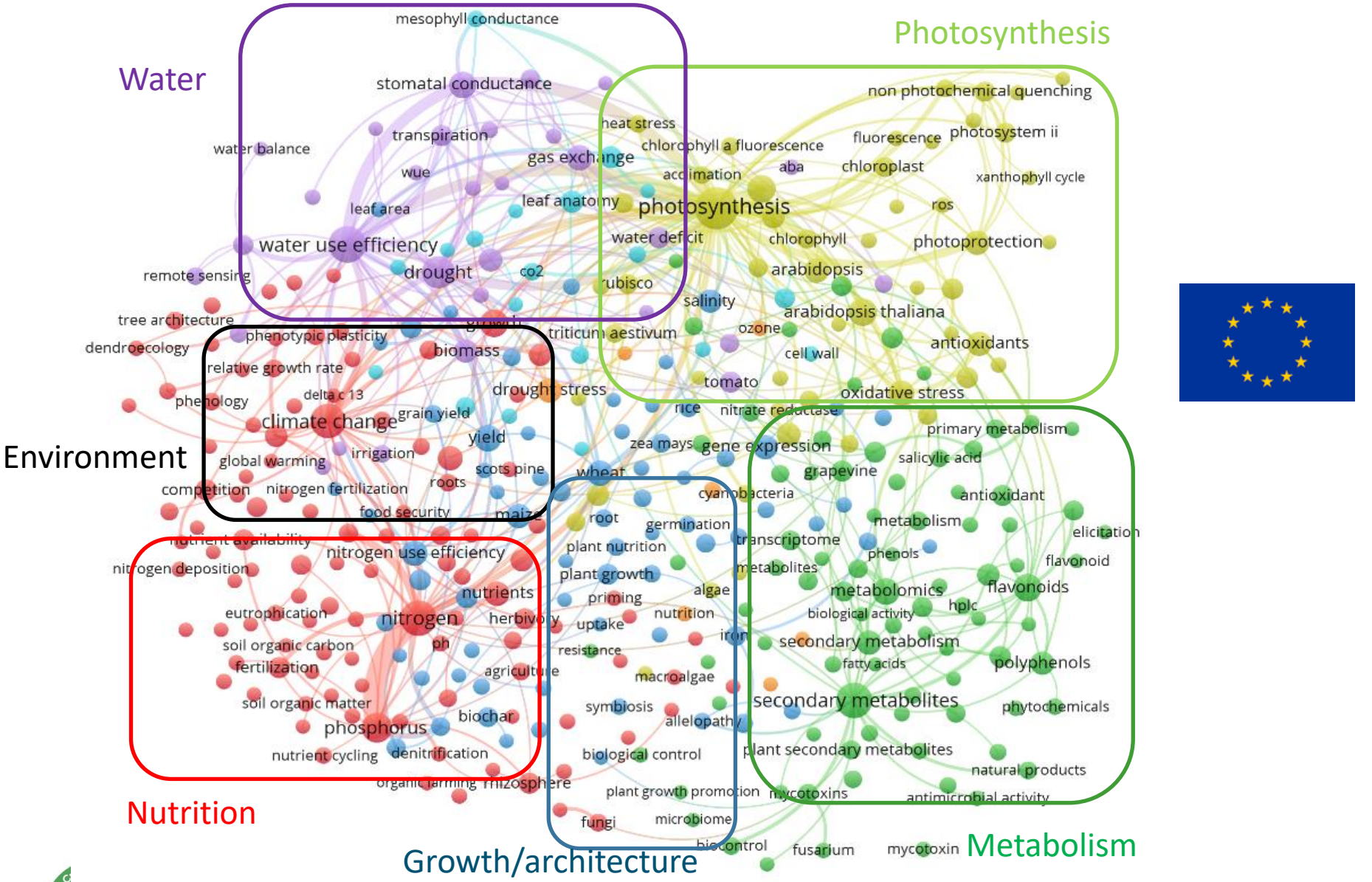
Keywords (>24 occurrence) associated to WP1 selected traits (Yield, Sustainability) as cited by authors of the 14,053 publications published by UE28 institutions (2015-2019)

WP4 literature screening



Keywords > 24 occurrences

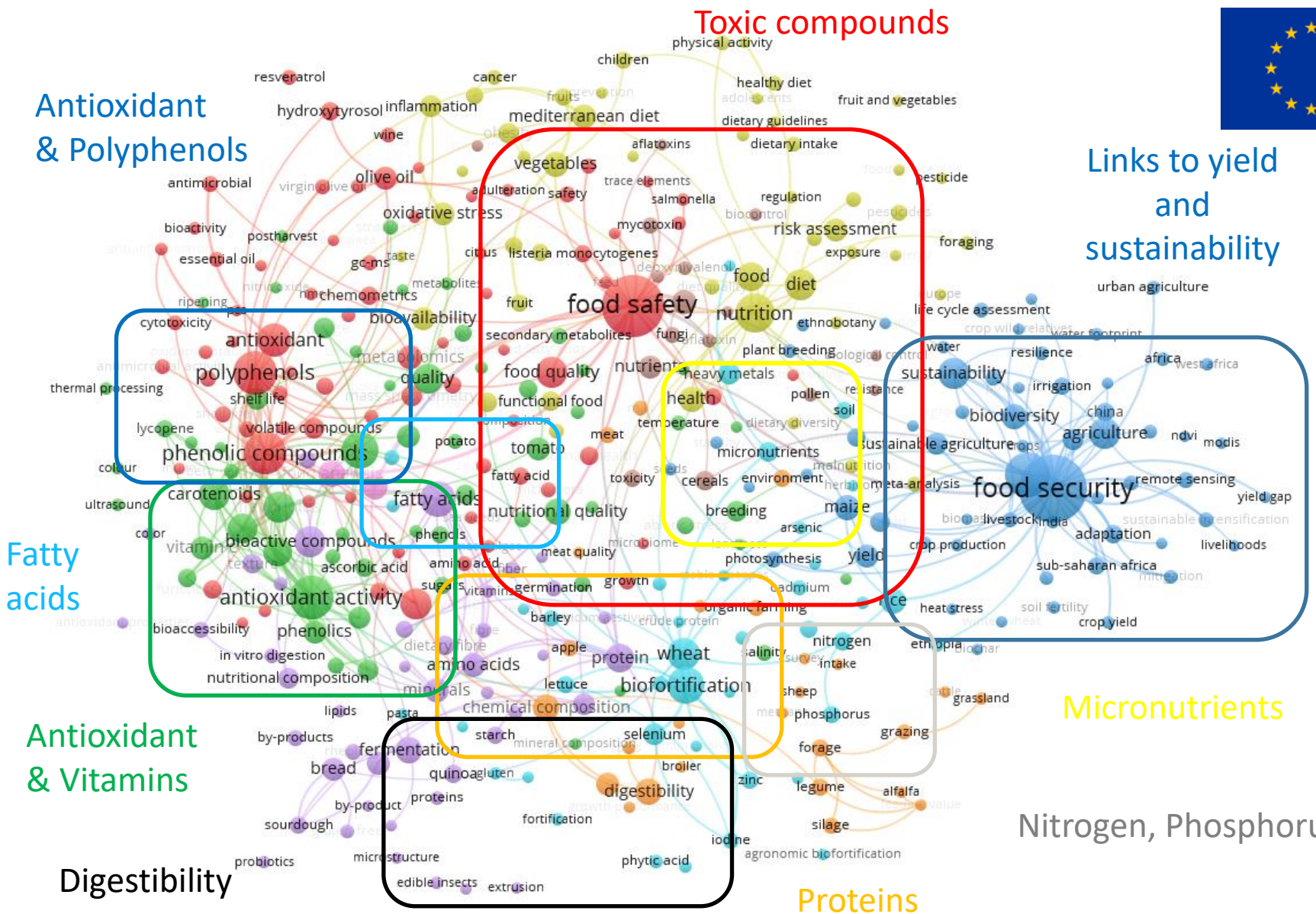
Network of keyword co-occurrence *(Yield, Sustainability)* helps defining main research fields



The network represents the co-occurrences of the main author keywords (minimum 20 occurrences, or 370 keywords) and the links indicate the existence of at least 5 publications with the 2 terms (threshold: 5, files Vosviewer network-Keywords-DE-20min-link-5-map.txt and network-Keywords-DE-20min-link-5-net.txt).

- ***Nutritional quality:* *General analysis (> 10,000 publications)***

Keywords Network of **keyword co-occurrence** defines **research fields**



P.eu

Main actors (institutions) in all fields

Publications by EU28 institutions (threshold: at least 200 publications, 2015-2019 period).

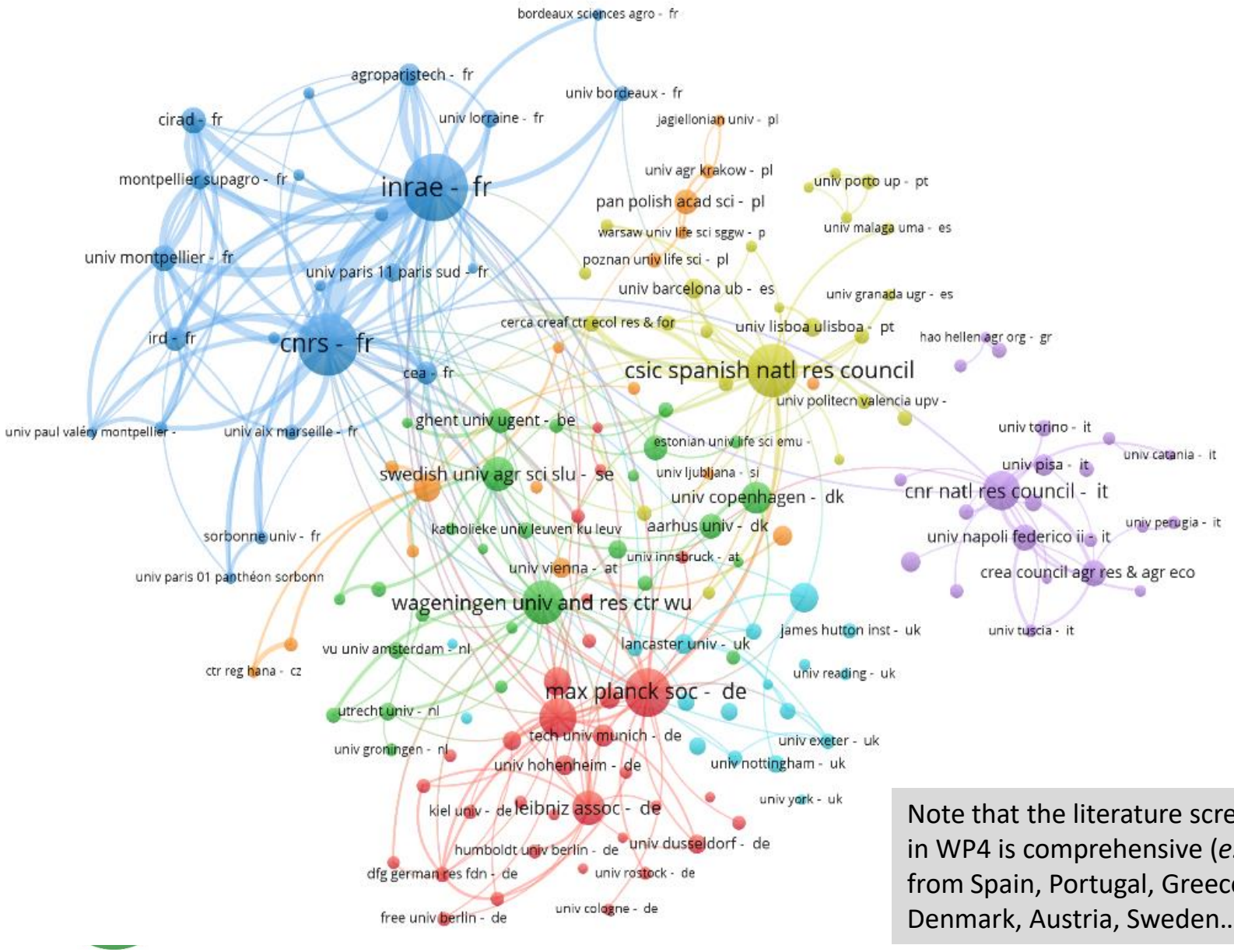
Main actors in UE28 (> 200 publications)	Publications 2015-2019	Publications with UE28	% publications with UE28
INRAE - FR	1012	351	34,7%
CNRS - FR	885	345	39,0%
CSIC Spanish Natl Res Council - ES	690	281	40,7%
Max Planck Soc - DE	574	271	47,2%
Wageningen Univ and Res Ctr WUR - NL	496	231	46,6%
Helmholtz Assoc - DE	413	194	47,0%
CNR Natl Res Council - IT	405	141	34,8%
Leibniz Assoc - DE	331	126	38,1%
Swedish Univ Agr Sci SLU - SE	323	159	49,2%
Univ Copenhagen - DK	297	118	39,7%
BBSRC Biotech & Biol Sci Res Council - UK	266	98	36,8%
Univ Gottingen - DE	247	64	25,9%
Acad Sci Czech Rep - CZ	245	118	48,2%
CREA Council Agr Res & Agr Economics - IT	215	60	27,9%
Univ Montpellier - FR	210	73	34,8%
Univ Napoli Federico II - IT	210	72	34,3%
Cirad - FR	206	40	19,4%
Ghent Univ UGent - BE	201	95	47,3%
Aarhus Univ - DK	200	80	40,0%

Source Web of Science Clarivate Analytics – 2015-2019 – Treatment INRAE CNRS 2020 - Article, Review, Proceeding Papers or Letters

Partner of CropBooster-P

Collaborations of the main institutions (which have at least 200 publications)

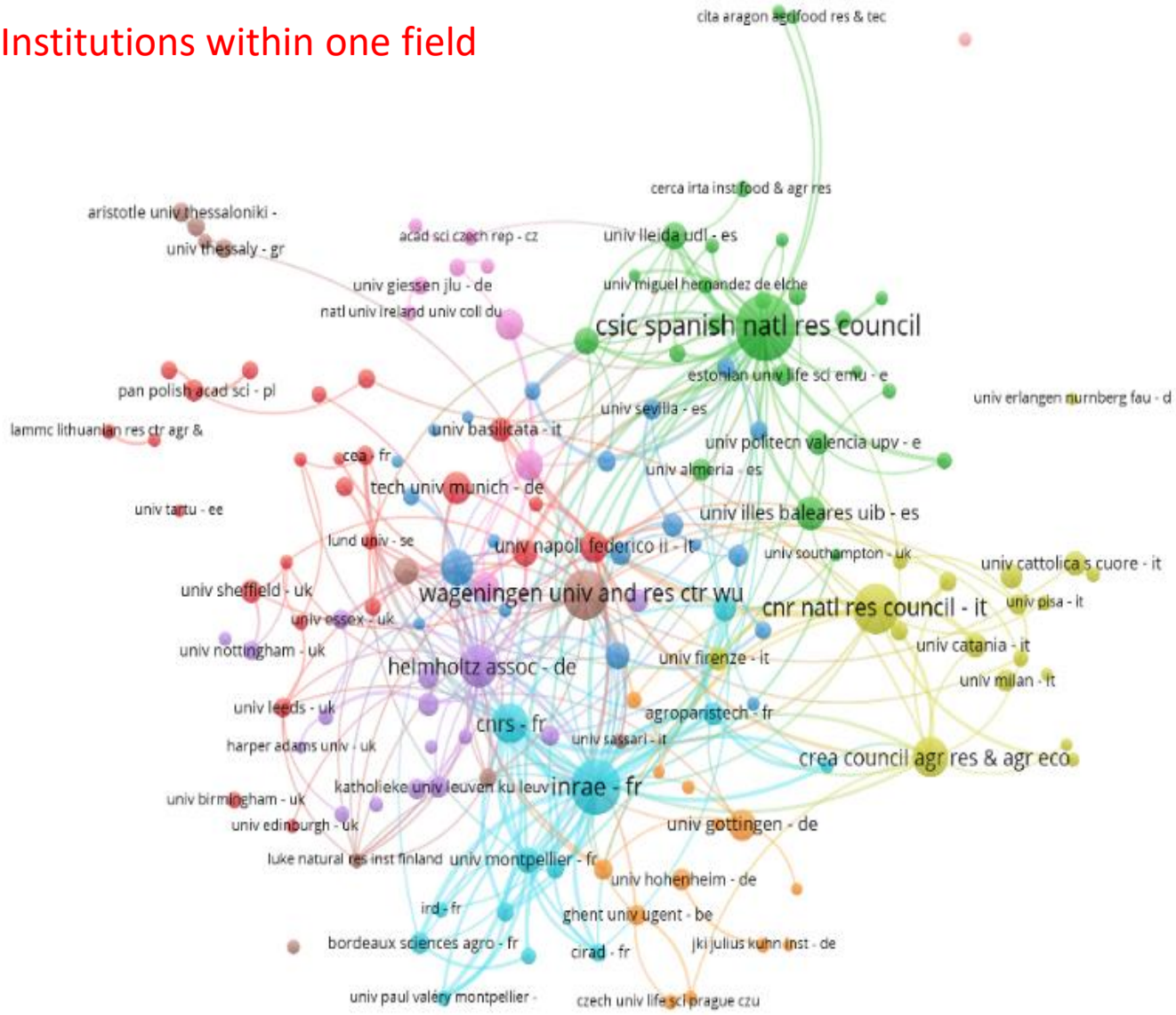
The links shown correspond to a minimum of 10 co-publications between the institution and its partner



Note that the literature screening performed in WP4 is comprehensive (*e.g.* institutions from Spain, Portugal, Greece, Poland, Denmark, Austria, Sweden…),

UE28 institutions with other UE Institutions within a field
e.g. Water Use Efficiency
(threshold: 5 occurrences, links> 1)

Institutions within one field



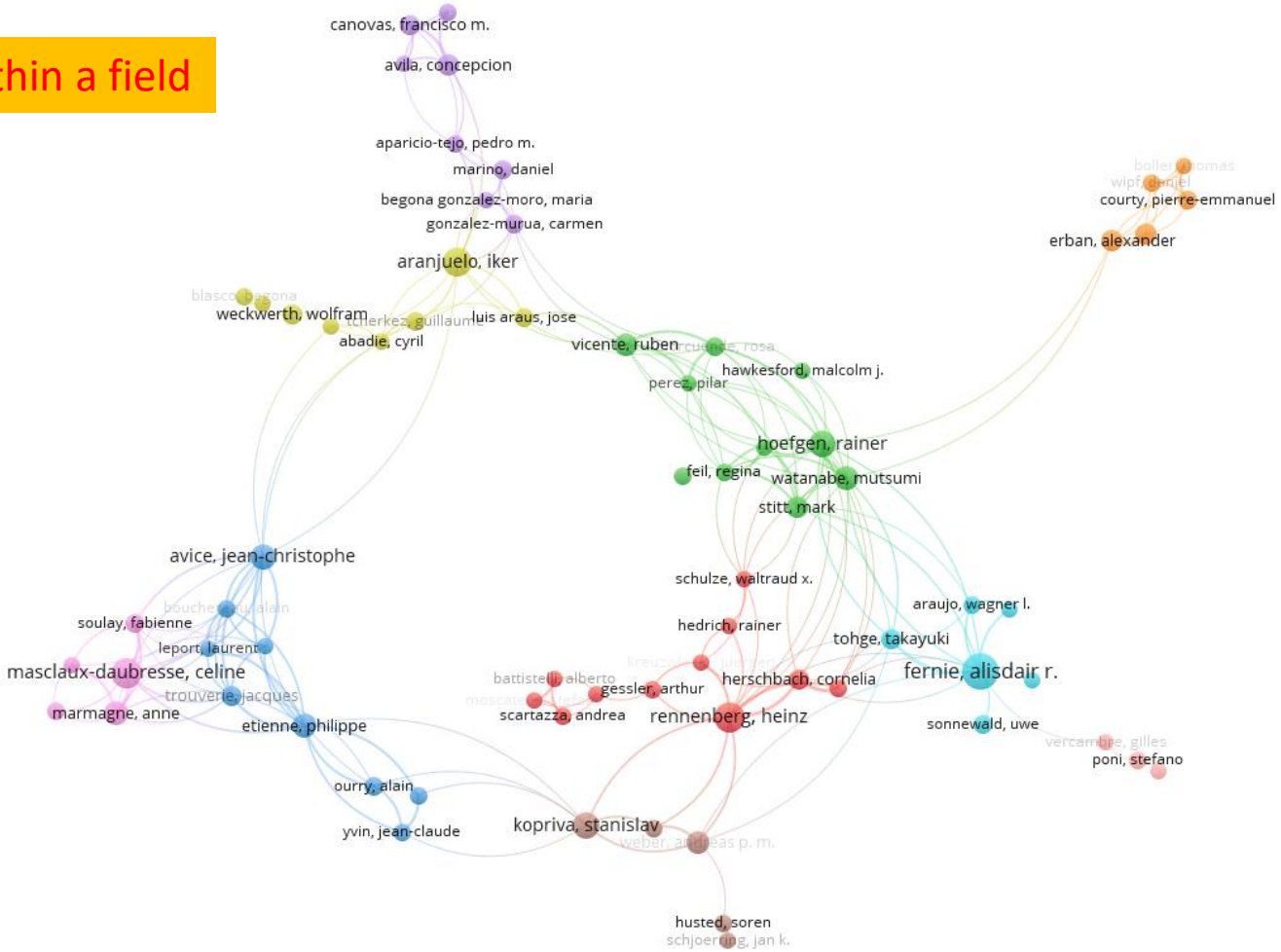
Relative impact of UE Institutions and their interactions within a specific field

Etc...

Mains actors in a specific field and their interactions
e.g. Source-sink balance

Main actors within a field

Contacted
Focus group
coordinator



Etc...

- **Source-sink balance**

Main actors within a field: Focus Group

Contacted Focus group coordinator

Name	Rank	Affiliation	Country/Region	Web of Science Documents	Times Cited	Category Normalized Citation Impact	% Docs Cited	% Documents in Q1 Journals
Poni, Stefano	1	Catholic University of the Sacred Heart	ITALY	6	58	1.57	83.33%	100%
Sonnewald, Uwe	1	University of Erlangen Nuremberg	GERMANY (FED REP GER)	6	65	2.36	100%	100%
Palliotti, Alberto	3	University of Perugia	ITALY	5	41	1.23	80%	100%
Yin, Xinyou	3	Wageningen University & Research	NETHERLANDS	5	37	1.78	80%	100%
Luquet, Delphine	3	CIRAD	FRANCE	5	20	0.88	80%	100%
Clement-Vidal, Anne	6	CIRAD	FRANCE	4	10	0.69	75%	100%
Masclaux-Daubresse, Celine	6	AgroParisTech	FRANCE	4	105	4.93	100%	100%
Masclaux-Daubresse, Celine	6	Universite Paris Saclay	FRANCE	4	105	4.93	100%	100%
Masclaux-Daubresse, Celine	6	INRAE	FRANCE	4	105	4.93	100%	100%
Fernie, Alisdair R.	6	Max Planck Society	GERMANY (FED REP GER)	4	82	2.16	100%	100%
Genard, Michel	6	INRAE	FRANCE	4	67	2.3	100%	100%
Greiner, Steffen	6	Ruprecht Karls University Heidelberg	GERMANY (FED REP GER)	4	59	1.81	100%	100%
Dai, Zhanwu	6	Universite de Bordeaux	FRANCE	4	41	1.78	100%	100%
Dai, Zhanwu	6	INRAE	FRANCE	4	41	1.78	100%	100%
Trumbore, Susan	6	Max Planck Society	GERMANY (FED REP GER)	4	147	1.89	100%	100%
Dingkuhn, Michael	6	CIRAD	FRANCE	4	12	0.67	75%	100%
Delrot, Serge	6	Universite de Bordeaux	FRANCE	4	41	1.78	100%	100%
Delrot, Serge	6	INRAE	FRANCE	4	41	1.78	100%	100%
Kuzyakov, Yakov	6	University of Gottingen	GERMANY (FED REP GER)	4	34	2.36	100%	100%
Vercambre, Gilles	6	INRAE	FRANCE	4	67	2.3	100%	100%

Major Players in Private-Public-Partnerships inside EU countries

●Applied Research communities (Private companies, R&D services of Cooperatives, Technical Institutes, networks of Experimental Stations etc.).

Method:

- Screening of the scientific production (**WoS**) during **five years (2015-2019)** (funding e.g. REMIX – H2020 – 727217, BACI – H2020 – 640176, FACCE SURPUS – H2020 – 652614, GoodBerry – H2020 – 679303, MycoKey – H2020 – 678781, PAPETS - FP7 – 323901, Innovine - FP7 – 311775, Watbio - FP7 – 311929…)
- List of actors coming from the biotechnology industries also inventoried using available **lists of previously funded projects by EU, DFG, ANR… + GABI** funded projects in Germany, **Biovegen** projects in Spain, private companies involved in the French Investments for the Future (**PIA**), private partners of the **French GIS-BV** (public private partnership for plant biotechnologies)…

Günter Strittmatter, Heinrich-Heine-Universität Düsseldorf, Germany
Peter Westoff, Heinrich-Heine-Universität Düsseldorf, Germany
Francesco Loreto, CNR, Roma, Italy
Erik Murchie, UNOTT, Nottingham, UK
Rene Klein Lankhorst, WUR, Wageningen, NL
Pablo Vera, IBMCP CSIC, Valencia, Spain
Gonzaga Ruiz de Gauna, Biovegen, Madrid, Spain
Peter Rogowsky, INRAE, Lyon, France
Norbert Rolland, INRAE/CNRS, Grenoble, France
Mathias Pribil, Univ. Copenhagen, Denmark







Major Players in Private-Public-Partnerships:

Inside Germany, and interaction of German PPPs with EU countries

1 Germany/Private Sector

- KWS SAAT SE & Co. KGaA
- Saaten Union Biotec GmbH
- BASF SE
- Norddeutsche Pflanzenzucht Hans Georg Lembke KG
- Bayer CropScience AG
- Nordasaat Saatzuchgesellschaft mbH

1 Germany / Public Sector

- Leibniz-Institut für Pflanzengenetik u. Kulturpflanzenforschung Gatersleben
- MPI f. Pflanzenzüchtungsforschung Köln
- MPI f. mol. Pflanzenphysiologie Golm
- Heinrich-Heine-Universität Düsseldorf
- Justus-Liebig-Universität Gießen
- Georg-August-Universität Göttingen
- Forschungszentrum Jülich
- Universität Hohenheim
- Christian-Albrechts-Universität zu Kiel
- Martin-Luther Universität Halle-Wittenberg

Major Players in Private-Public-Partnerships:

Inside France, and interaction of French PPPs with EU countries

2 France / Private Sector

- Bayer CropScience
- BASF SE
- Vilmorin
- Limagrain
- Innolea
- RAGT Semences
- Florimond Desprez
- Momont / KWS France
- Euralis/Caussade
- Syngenta
- Gautier Semences
- MAS Seeds
- Agri Obtentions
- Secobra
- Danone
- Nestlé
- Roquette
- Vegenov BBV

- Arvalis
- Vegepolys Valley
- Terres Inovia
- Sofiproteol
- Gnis

2 France / Public Sector

- **INRAE**
- **CNRS**
- **Cirad**
- **CEA**
- **IRD**
- **Institut Agro**
  (fusion of SupAgro and AgroCampusOuest in Montpellier)
- **Université Paris-Saclay**
  (incl. AgroParisTech + Université Paris-Sud)

Etc…

https://www.cropbooster-p.eu/data/upload/files/d4-1-final-report-17-12-2020.pdf
https://www.cropbooster-p.eu/the-project/project-results.html

Work package 4: International Cooperation [Months: 1-36]
INRAE, WR, VIB, WU, CNR, EPSO, UDUS, UNOTT, CNRS, UCPH, ULANC, USAMV CLUJ, ESA, ACTA

Task 4.2. This task aims to link research communities identified during task 4.1 by organizing joint meetings betweeen plant scientists (M12-M24 ->M28).
Task leader: **INRAE**; other partners: WR, VIB, WU, CNR, EPSO, UDUS, UNOTT, JKI, CNRS, UCPH, ULANC, USAMV, ACTA, ESA

- Organize networking activities with the different Research communities to identify experts for sustainable improvement of crop yield, and nutritional quality (link with WP1).

- Organize a joint meeting between European plants scientists from different disciplines and ongoing research programs to inventory areas of sustainable improvement of crop yield, and nutritional quality.

- Assemble an expert panel to review strategies (see task 4.3)

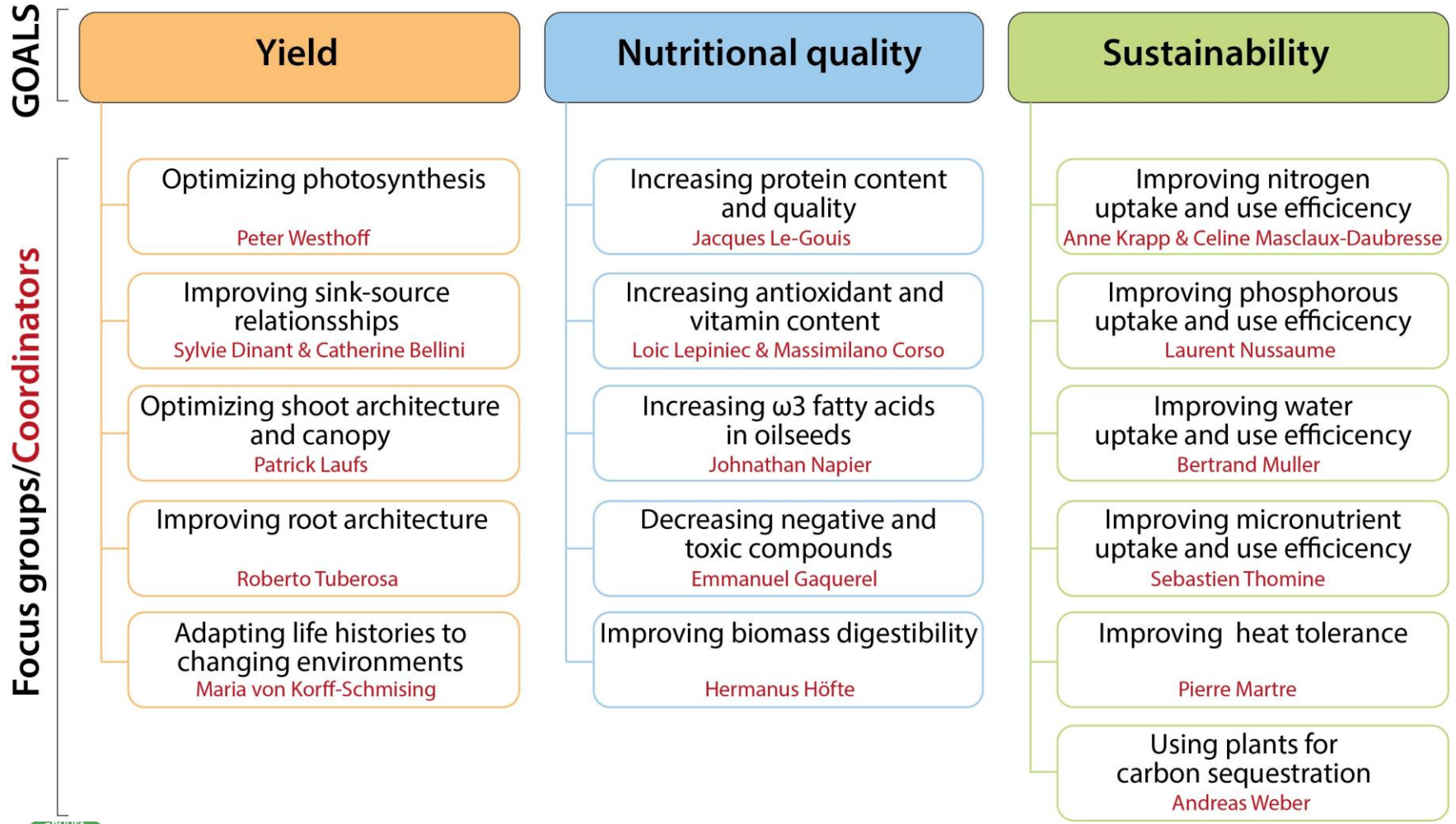
Focus groups meetings early 2020

WP4 meeting June 2021

Focus groups presentations

Focus groups & their coordinators

(According to WP1, WP2, and literature screening in WP4)



Focus Groups: Tasks of Coordinators

1. **Gathering a team of experts**

●Organize networking activities with the different Research communities

2. **Report (end of January 2021)**

The coordinators of the 15 "Focus Groups", established contacts with an average of 9 experts per "Focus Group". **Altogether, this approach involved more than 130 experts, from 70 institutes or universities and 15 countries.**

- Status quo of research in the field
  - Current know-how
  - Most relevant latest research results
  - Trends in research, new technology applied or potentially applicable
- Future challenges in the field to be addressed with high priority
  - What are the most relevant unsolved questions (questions scientific questions, societal and economic challenges)
  - Aspects/opportunities for application of research results
- Action points for a future research program in the field
  - What needs to be done to solve the scientific questions and to meet the societal and economic challenges ?
  - Projects with application relevance
  - What needs to be done to support the translation of research results into societal and economic value?

3. **Presentation/discussion of report at Versailles-Meeting (8-9 June 2021)**

● A joint meeting between (88) European plants scientists from different disciplines

4. **Coming to a joint proposal of action points adjusted between all Focus Goups**

Presentations Meeting Versailles June 8-9 2021 of WP4.
During these 4 days we welcomed high level speakers. All presentations can be viewed via the following link: https://www.cropbooster-p.eu/the-project/presentations.html

Work package 4: International Cooperation [Months: 1-36]
INRAE, WR, VIB, WU, CNR, EPSO, UDUS, UNOTT, CNRS, UCPH, ULANC, USAMV CLUJ, ESA, ACTA

Task 4.3. Reviewing scientific and technical strategies on the scientific basis of existing and future tools and approaches (M12-M33)

Task leader **CNRS**; other partners: WR, WU, CNR, EPSO, UDUS, UNOTT, JKI, INRA, UCPH, ULANC, ACTA

This task aims to get a complete overview of methods and strategies that will be supplied to WP5:

- Literature research and expert assessment to discuss and resume available strategies, options, technologies and present limitations to improve yield, quality and sustainability in different crop species. Report on state of the art, knowledge gaps, trans-disciplinary frontiers, novel technologies and knowledge synthesis needs.

- Writing of scientific reviews to propose the best scientific options to further improve the selected crops in future agriculture. Publishable summary, statement of methodology used, main results and meta-data for white papers. Joint review articles and research visions submitted for open access publication (work to be done in coordination with WP5).

Focus groups reports and reviews (November 2021)
Deliverable 4.2. White Paper and Scientific Basis of the Strategic Research Agenda
=> The Deliverable 4.2 (distributed to partners) is available via the link below:

https://www.cropbooster-p.eu/the-project/project-results.html

Conclusions (Deliverable 4.2): Suggestion of Topics for Research Agenda

In summary, the reports of the 15 "Focus Groups" and the presentation and discussion of these reports during an Online-Workshop on June 08/09, 2021, led us to the recommendation of the following high priority topics for a future EU research agenda in the field of plant sciences, all under the headline "Better Crops for Tomorrow's Needs":

Climate crisis

Adapt crops to extreme conditions

- Breeding for multiple abiotic stress resistances: Heat, drought, salinity, cold, water-logging etc..
- Breeding for adaptation to eCO2 and mitigation (sequestration of CO_2)

Biodiversity crisis

Make more efficient use of scarce commodities
Create more space for nature and Agro-ecology

- Breeding for more efficient use of water, phosphate, nitrogen, micronutrients etc..

Food crisis

Increase (at least stabilize) yield
Increase nutritional quality and safety

- Breeding for yield in conventional agriculture, agroecology approaches, organic farming.
- Breeding for protein composition, vitamins, minerals, fatty acids, antioxidants etc..

Energy crisis

Increase yield
Increase biomass digestibility

- Breeding for biomass yield and composition (bioeconomy).

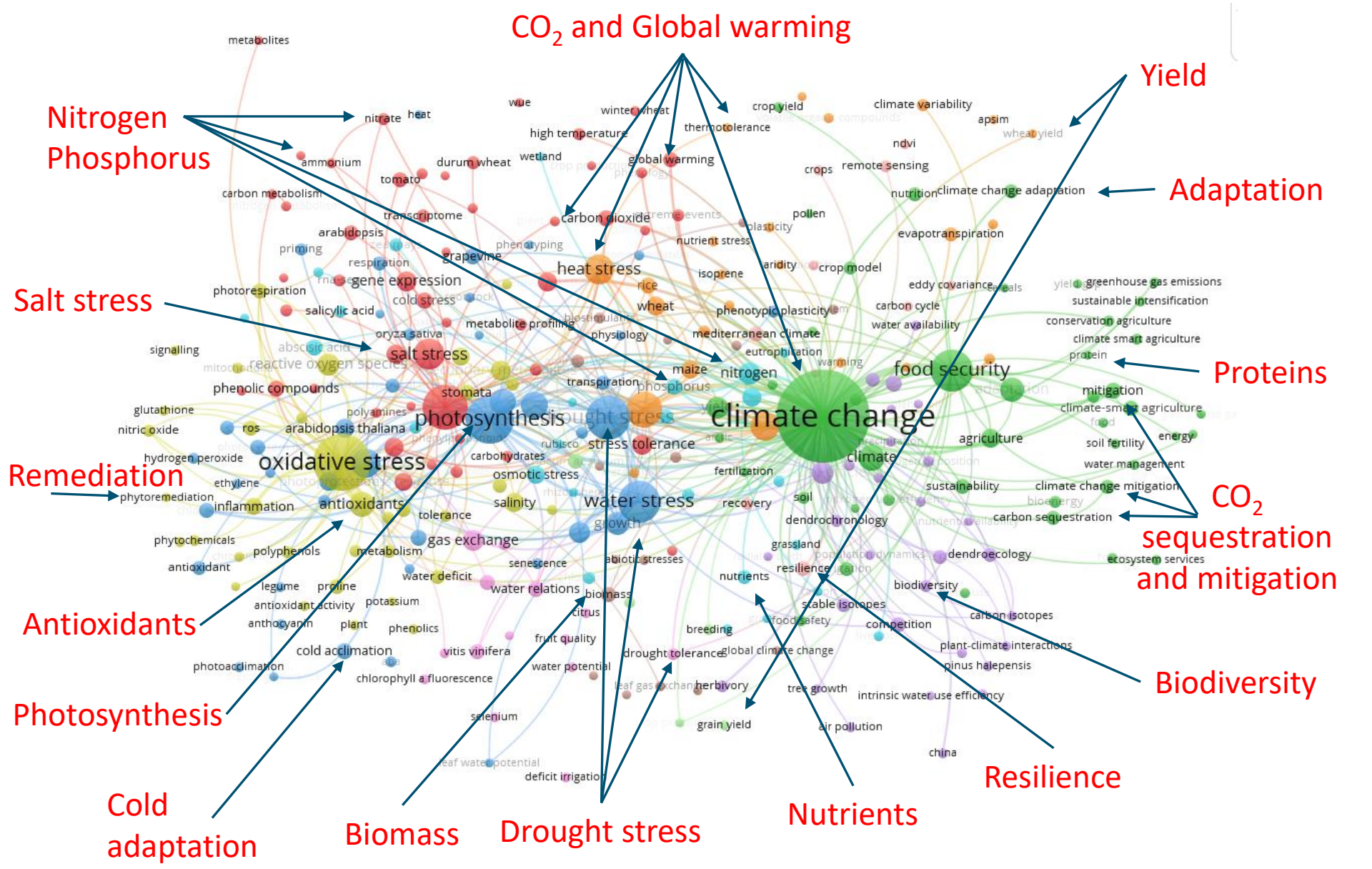
And technology crisis

- Alternatives to classical breeding

Mitigating the effects of global climate change
–> Sustainability & Yield & Nutritional quality (> 24000 publications)

- **Climate change**
- **Stress**

Combined programs are obvious: links between topics and priorities



Review papers and research visions to feed WP5

Focus groups reports and reviews (November 2021)

Participation to the Opinion paper in "Biology" (2021) coordinated by WP6

Experts in Focus Groups participated to the writing of several review articles coordinated by WP1 in a special issue of "FES"

A short Review article (in progress) coordinated by WP4 in the same special issue of "FES" to bring more visibility to the huge work performed by Focus Groups (cf. report D4.2).

Participation to the writing of the Roadmap coordinated by WP5

Other impacts of the "Focus Group" strategy:

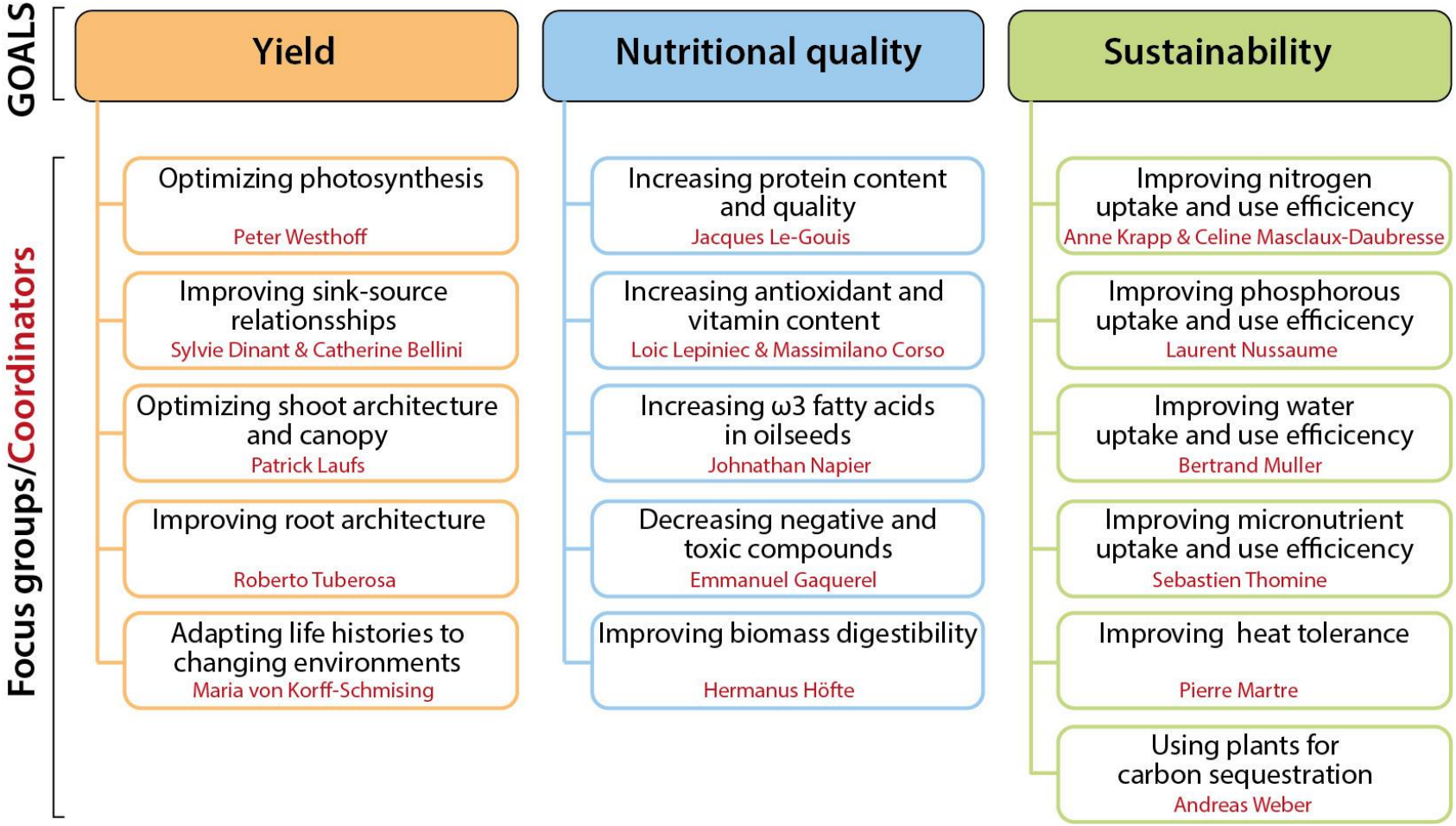
Review articles (acknowledging CropBooster) written by Focus Groups members (Micronutrients; WUE) (*e.g.* ***New Phytologist*** (October **2021**) 232:25–41, doi: 10.1111/nph.17610; ***Journal of Experimental Botany*** (March **2022**) 73:1789–1799, https://doi.org/10.1093/jxb/erac014)

Members of two Focus Groups (NUE-Proteins) contacted their National Contact points for the Cluster 6 being representative of the Cluster 6 Programme Committee, to co-support a new topic in the working programme 2023-2024 of H. Europe: Research and innovation action (RIA) topic "HORIZON-CL6-2023-FARM2FORK Boosting nitrogen use efficiency for sustainable EU-grown plant-protein yield and quality and for mitigating environmental impacts"

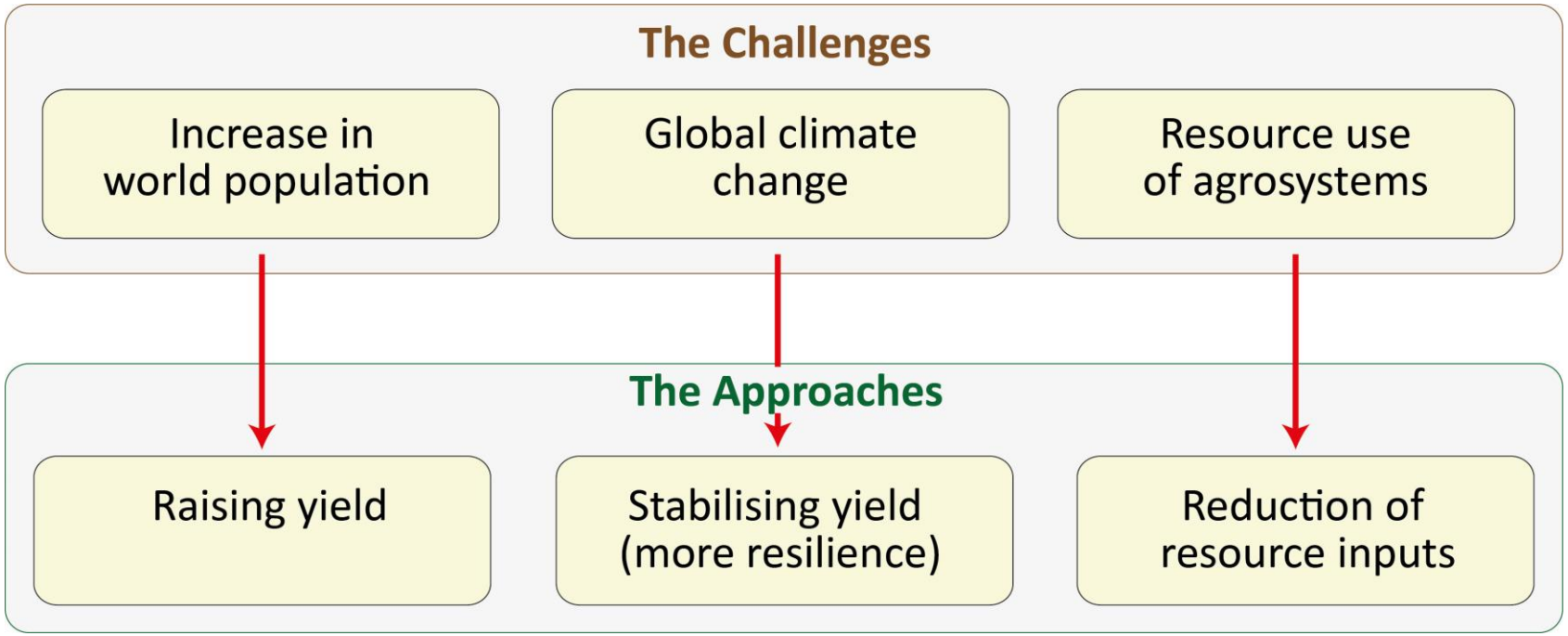
Conclusions from the Focus Groups

- Thoughts on the Research Agenda & Strategy -

The Focus Groups



The Great Challenges for Agriculture



Overarching Topics for a Research Agenda

Topic 1: High-Yielding Crops with Less Input

- Raising the yield potential by optimising photosynthesis
- Improve nitrogen and phosphorus use efficiencies
- Optimise water use efficiency and its interaction with photosynthesis
- Tinkering with and exploiting of leaf and plant architecture for increases in yield potential
- Develop novel strategies for plant protection

Topic 2: Resilient Crops Coping with Climate Change

- Exploit the global natural and agricultural biodiversity for novel crops to be introduced into European agriculture
- Optimise heat AND cold tolerance of crops with an emphasis on yield stability
- Devise strategies for protecting European agriculture against the rise of novel pathogens

Topic 3: Plants for efficient carbon sequestration

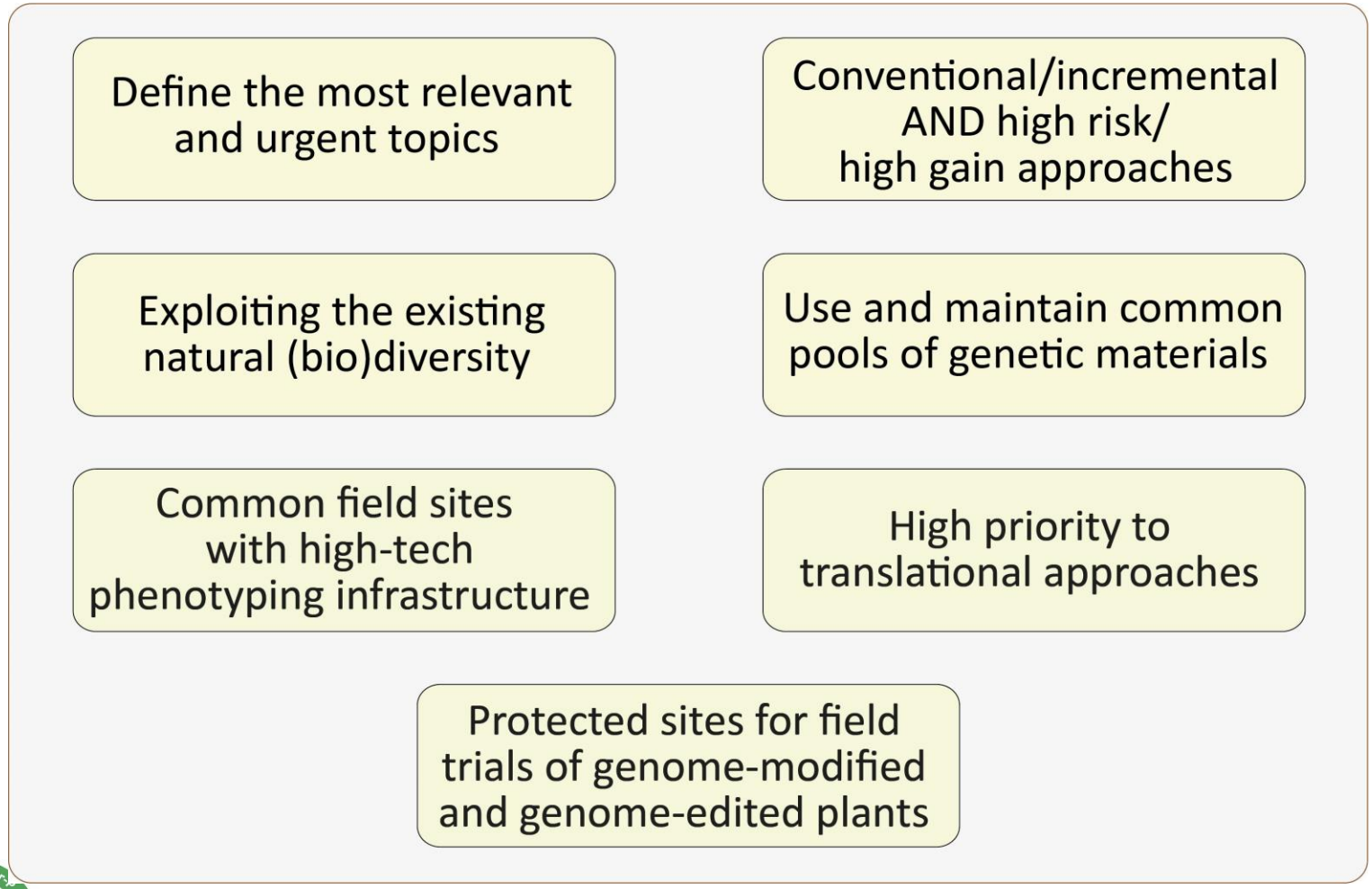
- Evaluate systematically the carbon sequestration capacities of a broad spectrum of plants/crops
- Optimise the carbon sequestration capacities of suitable crops

Topic 4: Plants Replacing Meat in Healthy Diets

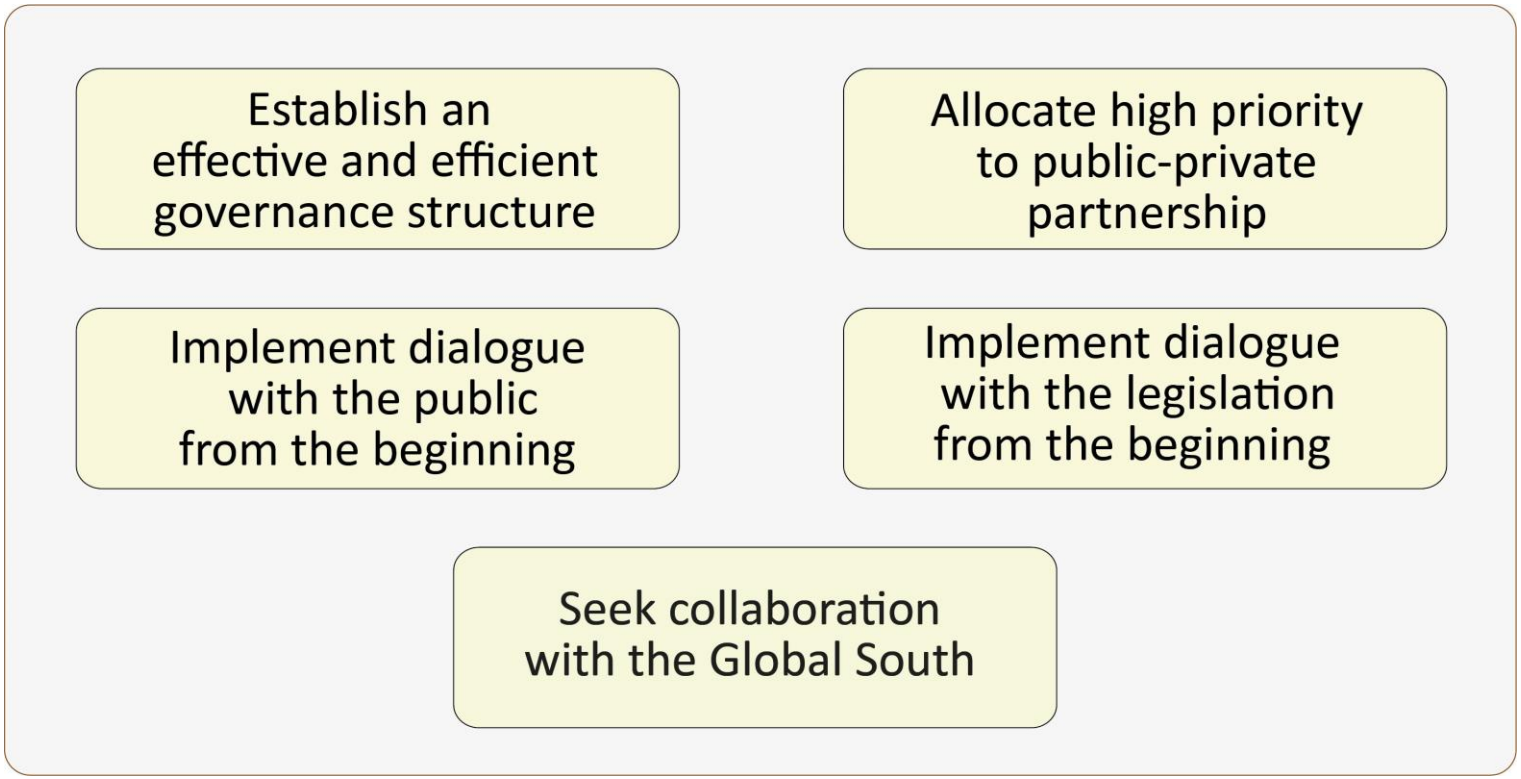
- Generate the scientific basis for the introduction of high-yielding protein crops (legumes) into European agricultural systems
- Investigate the impact of climate change on the nutritional quality of crops
- Understanding the overall nutritional consequences of replacing meat by protein crops:

  Which other features do protein crops need as a healthy replacement of meat?

Strategic Considerations on the Research Agenda



Considerations on the Organisational Concept



Acknowledgements

Special thanks to:
Evelyne Barbin
Laurence Piguel
Christina Gacic

Task 4.1

- Dominique Fournier, INRAE, Montpellier, France
- Rene Klein Lankhorst, WUR, Wageningen, NL
- Francesco Loreto, CNR, Roma, Italy
- Jacqueline Martin-Laffon, CNRS, Grenoble, France
- Bertrand Muller, INRAE, Montpellier, France
- Erik Murchie, UNOTT, Nottingham, UK
- Philippe Nacry, INRAE, Montpellier, France
- Mathias Pribil, Univ. Copenhagen, Denmark
- Peter Rogowsky, INRAE, Lyon, France
- Norbert Rolland, INRAE/CNRS, Grenoble, France
- Gonzaga Ruiz de Gauna, Biovegen, Madrid, Spain
- Günter Strittmatter, Heinrich-Heine-Univ. Düsseldorf, Germany
- Pablo Vera, IBMCP CSIC, Valencia, Spain
- Peter Westoff, Heinrich-Heine-Univ. Düsseldorf, Germany

Tasks 4.2 and 4.3

Catherine Bellini, INRAE, Versailles, France + UMEA Univ., Sweden
Massimiliano Corso, INRAE, Versailles, France
Sylvie Dinant, INRAE, Versailles, France
Emmanuel Gaquerel, Univ Strasbourg, France
Alain Gojon, INRAE, Montpellier, France
Hermanus Höfte, INRAE, Versailles, France
Anne Krapp, INRAE, Versailles, France
Patrick Laufs, INRAE, Versailles, France
Jacques Le-Gouis, INRAE, Clermont-Ferrand, France
Loïc Lepiniec, INRAE, Versailles, France
Pierre Martre, INRAE Montpellier, France
Céline Masclaux-Daubresse, INRAE, Versailles, France
Bertrand Muller, INRAE, Montpellier, France
Johnathan Napier, Rothamsted, UK
Laurent Nussaume, CEA, Cadarache, France
Norbert Rolland, INRAE/CNRS, Grenoble, France
Sébastien Thomine, CNRS, Gif sur Yvette/Paris Saclay, France
Roberto Tuberosa, Univ Bologna, Italy
Günter Strittmatter, Heinrich-Heine-Univ. Düsseldorf, Germany
Maria von Korff-Schmising, Heinrich-Heine-Univ. Düsseldorf, Germany
Andreas Weber, Heinrich-Heine-Univ. Düsseldorf, Germany
Peter Westoff, Heinrich-Heine-Univ. Düsseldorf, Germany