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CropBooster-P

Deliverable 1.6

Title: Preparatory documents ready for discussions during workshop with SHG on Sustainability

Start date of the project: **November 1st, 2018** / Duration: 36 **months**
Planned delivery date: M5 (March 2019)
Actual submission date: 31 March 2019
Work package: WP1 / Task: 1.4

Work package leader: ULANC
Deliverable leader: INRA

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Dissemination level	Public

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1. Introduction

The future demands on our crops will be tremendous, both in terms of level and stability of production and nutritional security. And food systems have to adapt to the transition to a non-fossil carbon economy, climate change, and globally reduce most of its negative externalities, improving its sustainability. These will give a new purpose to the rural economy of Europe. So far, however, Europe has no long-term strategy for future proofing its crops to allow these possibilities to be realised. How to sustainably increase yields and ensure nutritional quality, i.e. how adapting crops for the future climates of Europe, but doing so with the needed decrease in inputs such as water, chemical fertilisers and pesticides? Obtaining an overview on the current state of sustainability development of crop production within Europe including breeding methods and technologies, and breeding targets from traits to genes, would therefore provide an insight into various aspects of plant improvement, contributing to a toolbox that would prove invaluable to the future directions of crop research.

The Brundtland Commission described Sustainability as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". There are three pillars defining Sustainability: Economical, Societal and Environmental Sustainabilities. Task 1.4 will center its action on Environmental Sustainability.

The WP1-Research toolbox Task 1.4 will comprise of an overview of the current and future focus areas and approaches to improve sustainability of crop production. This will include a survey of published scientific literature for all major aspects of crop sustainability in major, minor and niche crop species. Current and future methods and technologies to improve sustainability and existing geographical trends will be included in this study.

2. Objectives

WP1-Research toolbox Task 1.4 will map the different existing and future subject areas for sustainability improvement. These we expect to vary across the diverse agricultural regions of Europe. Literature studies, technology studies (incl. models) and trait studies will be performed to list and collect all available strategies, options and technologies to improve sustainability in different crop species. This will be cataloging exercise, yielding a bibliographic repository and internal database. In the end, common strategies/technologies/traits linking sustainability, quality and yield objectives will be identified and will serve as a basis for discussions with the SHG. Their expert advice will be important input to the toolbox (task 1.5).

3. Partners and fields of expertise

Organisation name	Short name	Country	Area(s) of specialization
Institut National de la Recherche Agronomique	INRA	France	• quantitative genetics, genetic control of tomato fruit quality (sensory and nutritional), fruit and vegetable quality in general • plant and crop physiology (maize, wheat, soybean, pea…), breeding, cultivar and species mixtures. • Large-scale Phenotyping, genomics, metabolomics…

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Organisation name	Short name	Country	Area(s) of specialization
			• agronomy, drought, nutrient use efficiency, water use efficiency, nitrogen, major crops, legumes, non-food crops.
Københavns Universitet	UCPH	Denmark	• photosynthesis; regulation of photosynthesis, chloroplast biology, thylakoid membrane • plant development, microProteins, tissue culture
Centre National de la Recherche Scientifique	CNRS	France	• essential metal (Fe, Mn) transport and seed storage, toxic metal uptake in plants • biochemistry, metabolic engineering and functional analysis of plant metabolism
University of Nottingham	UNOTT	UK	• plant and crop physiology, wheat, rice, photosynthesis • crop physiology, agronomy, drought, nutrient use efficiency, nitrogen, wheat
Europese Organisatie voor Wetenschappelijk Plantenonderzoek	EPSO	Belgium	EPSO's mission is to improve the impact and visibility of plant science in Europe, providing advice on science policy towards a strategic approach and critical mass funding for basic and applied research across Europe

4. Meetings and teleconferences

The following meetings and teleconferences have been held to discuss the project status and refine T1.4 work:

- **20th of November 2019 – F2F meeting**
  Kick-Off meeting CropBooster-P project, WUR, Wageningen, The Netherlands
- **28th of November 2018 – TELECONFERENCE**
  General framework of the CropBooster-P project, Task leaders of WP1 + several WPL
- **21st of January 2019 – TELECONFERENCE**
  Teleconference to discuss the sustainability concepts and the expected outputs of the T1.4 work - Task 1.4 partners
- **22nd of January 2019 – TELECONFERENCE**
  Update teleconference with Task leaders of WP1
- **31st of January 2019 – TELECONFERENCE**
  Status quo call - WPL1 + SR + task leaders WP1
- **12th of February 2019 – TELECONFERENCE**
  Status quo call, INRA team involved in CropBooster-P
- **14th of February 2019 – F2F meeting**
  F2F 1 day meeting on sustainability Task definition and planning, INRA core team leading Task 1.4
- **18th of February 2019 – TELECONFERENCE**
  Update on sustainability concepts Task leaders WP1 + People of INRA involved in Task 1.4
- **27th of February 2019 - TELECONFERENCE**
  Task leaders of WP1
- **27th of February 2019 – F2F Meeting**

F2F 1 day meeting on refining sustainability Task 1.4 definition and Ecosystem Services concepts, INRA core team leading Task 1.4

- **7th of March 2019 Teleconference- WP1 Task 1.3 partner**
  Discussed format of data collection, level of detail, deliverables and assigned responsibilities according to expertise and areas of interest. Created shared folder for internal data collection. Data collection in progress.
- **15th of March 2019 - TELECONFERENCE**
  Teleconference to discuss the format of data collection, level of detail, deliverables and assigned responsibilities according to expertise and areas of interest. Created shared folder for internal data collection. Data collection in progress - Task 1.4 partners
- **3rd of April 2019 – F2F meeting**
  F2F 1 day meeting to finalize the common understanding of the output of WP1, Leader WP1 and task leaders of WP1, VIB, Ghent, Belgium
- **4th of April 2019 – TELECONFERENCE**
  Status quo call with SR (define/rephrase proxy variables, set expectations for 2-day workshop, which are key for the Scenario building exercise)- SR + Task leaders of WP1

Future events:

- **15-16th of April – F2F meeting in PlantETP, Brussels- scenario building workshop (WP1 T1.1).**
- **25th of June 2019 – F2F ExCom meeting - progress of the CropBooster-P project – WP + Task Leaders, ULANC, UK**
- **11th of September - F2F meeting on progress of WP1**

5. Trend cards corresponding to sustainability facets

In preparation for the scenario building workshop, a list of relevant trends and issues focusing on subtask nutrition was collected within T1.1 from among the partners and assimilated into a long list of trends. These were further sorted according to relevance to the CropBooster-P project. A final shortlist of trends was proposed which contained trends pertaining to crop yield, nutrition and sustainability subtasks. These trends were then further processed into trend cards.

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List of trend considered for Scenario Building

Trends (in alphabetical order):

1) Aging Population
2) AI & Big Data
3) Alternative Nutrition Sources
4) Animal Welfare
5) Biofortification
6) Biotech
7) Blockchain
8) Cheaper Food
9) Circular Bioeconomy
10) Climate Change
11) Cultivar / Species Mixtures
12) Decline of Pollinators & Biodiversity
13) Declining Chemistry for Pest Control
14) Diet-related Chronic Diseases
15) Do-it-Yourself
16) E-Commerce
17) Economic Pressure on Farms
18) Electrification
19) Environmental Concerns
20) Fair Trade
21) Globalization
22) Healthy Lifestyle
23) ICT on the Rise
24) Increased Mechanisation
25) Intellectual Property
26) Land-Use Pressure
27) NBTs & Genetic Modification
28) Offering of Meat Alternatives
29) Organic Farming
30) Plant Beneficial Microbes
31) Population Growth
32) Power of the Online Public
33) Product & Research Regulation
34) Public Engagement in Research
35) Reduction of / Altered Genetic Resources Circulation
36) Renewable Energy
37) Resource Scarcity
38) Rising Disposable Income
39) Risk Sensitivity
40) Robotics
41) Self-Tracking / Quantified Self
42) Sustainability
43) Transparency
44) Urban Farming / Greenhouses
45) Urbanization

Most of these cards, if not all, are highlighting facets of the three pillars of sustainability: Environmental, Economical and Societal sustainabilities.

Example of trend card

Trend Card

Plant Beneficial Microbes

Description

As the discovery of new synthetic pesticides has become increasingly costly, the biopesticide market has been growing, including the exploration and use of plant beneficial microbes. These can act preventatively, suppress diseases, enhance the availability of nutrients and promote plant growth and rooting.[1]

Facts & Figures

- Increasing investment of agri start-ups in microbiome[2]
- Ca. €400M spent on "microbiome related research" in the first 2 years of H2020 (EU), investment up to €130M foreseen until 2020[3]
- The global human microbiome market would be worth USD 0.3 billion by 2019, and reach USD 0.7 billion by 2023[4]
- Rising number of scientific papers on microbiome research (2769 [2012] to 8431 [2016][5]

Stakeholders & Influencers

- Researchers/startups (seek funding, innovate)
- Consumers (demand)
- Farmers (supply)
- Supermarkets/retail (promotion)
- Government (regulation)
- NGOs (certification)

Related (Sub-)Trends

Pesticide free agriculture, Sustainability, Bio Boom

Relevancy: CropBooster-P

- Influence on land use, crop sustainability and productivity
- Reduced acceptance of conventional CPM
- Influence on food prices
- Enable new business models
- Certification and regulation (synthetic pesticides/fertilizers vs. biologicals)

Sources: [1]Poleatewich, A. (2018), "Utilizing beneficial microbes in a systems approach to plant disease management". [2]Waltz E. (2017), "A new crop of microbe startups raises big bucks, takes on the establishment", Nat Biotechl. 8;35(12):1120-1122. [3]EU MICROBIOME R&IMAPPING, DG RTD presentation. [4]OECD (2017), "The Microbiome, diet and health: Towards a science and innovation agenda", OECD Science, Technology and Industry Policy Papers, No. 42. OECD Publishing, Paris. [5]European Commission, Directorate-General for Research and Innovation (2018) Study on mission-oriented r&i on food system microbiomes by A. Malyska.

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6. Work plan for Task 1.4

Overall phases:

To facilitate data collection, and in line with Task 1.2 and 1.3, WP1 Task 1.4 is divided into distinct phases:

1) Definition of template, division of tasks among partners according to expertise and areas of interest (by M5 end)
2) Data collection/ filling templates (by M7 end)
3) Compilation and filling in the gaps in the collected data, arranging the collected information in a comprehensive format and upload to a central location (by M8 end)
4) Contribute to integration of the outputs of Task 1.2, 1.3 and 1.4, identify overlaps, trade-offs, etc. and align the data obtained by the different subtasks to generate a 'Research toolbox'.

Data collection templates:

- **MAPPING** - Bibliography: a comprehensive literature survey to identify Traits, and when available, pathways, processes and genes that have the potential to contribute to an increase in sustainability
- **GAPPING** - Gaps: identification of the gaps there are in our current knowledge that may hinder sustainability progresses

A 'mapping' and 'gapping' approach to identify traits, processes, and when available, pathways, processes and genes of which the potential can be exploited using a range of different technologies to increase Sustainability in distinct crops.

A common template between the subtasks of Work Package 1 - yield, nutrition and sustainability - is being developed in order to facilitate data collection and assimilation of overlaps between the subtasks for the final deliverable. This template will form the basis of a longer document outlining the current scientific progress and approaches known to improve plant traits. A technical annexe will also be included to summarize key technologies and methods to improve crop yield, nutrition quality and sustainability.

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The major Traits pertaining to Sustainability, and considered within the CropBooster-P template for data collection belongs to **Resources Use Efficiency and Stress Tolerance/Resistance.** Their relevance will be considered for major crops, niche crops/underutilized crops, and aquatic crops.

These Major Traits will be refined in Traits and Sub-Traits, as exemplified in the following, non-exhaustive, list:

1. Resource Use Efficiency:

- Nutrient Use Efficiency
  - Plant below-ground structure/morphology
    ~ influence of root architecture on canopy LUE
    * List of Sub-Traits: Root shape/size/SRA/Growth/Length, Branching...
    ~ influence of morphogenesis on root architecture plasticity, and NutUE
    ~ influence of architecture and plasticity on competition with weeds
  - Plant below-ground carbon physiology
    ~ Root exudates and their impact on plant nutrition:
    - direct impact on soil properties (pH, osmotic potential, …)
    - indirect impact through plant-soil feedbacks with microorganisms

    ~ Carbon storage in root sinks (link to climate changes, see also 4/1000 initiative, https://www.4p1000.org/):
    - direct impact of root architecture on C storage efficiency
      * List of Sub-Traits: Root shape/size/SRA/Growth/Length, Branching, ...
    - indirect impact of stored organic matter on water, nitrogen and phosphorus storage
      * List of Sub-Traits: impact of stored organic matter composition on soil fertility…

  - Nitrogen Use Efficiency
    ~ Nitrogen assimilation efficiency (transporters and metabolism)
    ~ Impact of low nitrogen on photosynthesis efficiency and biomass composition (metabolism, protein/carbohydrates)
  - Phosphorus (Pi) Use Efficiency (link to decrease of natural resources)
    ~ Phosphorus assimilation efficiency (transporters and metabolism)
    ~ Impact of low Pi on biomass composition and photosynthesis
  - Heavy metals (Cu, Mg, Mn…) (link to task 1.2 Yield, link to land pressure)
    ~ Phytoremediation of contaminated soils (link to land pressure)
    ~ Heavy metals assimilation (transporters) and impact on photosynthesis efficiency
  - List of main other nutrients, continued…

2 Stress Tolerance/Resistance

- Drought tolerance (link to climate changes)
  ~ Water assimilation and storage efficiency, transport, evapotranspiration...
  ~ Crop varieties tolerant to drought stress (specific proteins and metabolic compounds)
- Heat Stress Tolerance (link to climate changes)
  ~ Crop varieties tolerant to heat stress (specific proteins and metabolic compounds)
- Salinity Tolerance (link to land pressure)
  ~ Impact of salinization on growth rate
  ~ Selection of crop varieties tolerant to salt stress

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~ Phytoremediation of saline soils
~ Salt transporters and root-leaf transport

- Cold Tolerance
  ~ Crop varieties tolerant to cold stress (specific metabolic compounds)
- Frost Resistance
  ~ Crop varieties tolerant to frost (specific metabolic compounds)
- Physical constrains resistance
  ~ Crop varieties tolerant to mechanical constraints (wind…)
- Ozone/UV/Oxydative stress tolerance (link to climate changes)
  ~ Photoprotection and light assimilation efficiency (see Task 1.2 Yield)

- Trade-off between Yield and Nutrition and Sustainability

7. To be discussed at the workshop

- Bibliographic review to be performed at the TRAIT scale, and when possible, at Pathway and Gene levels. Some of the key traits will not have clear genes/pathways.

- Traits involved in Plant-to-Plant interactions: Light/Nutrient/Molecular cues and related Pathways used by the plants to detect neighbour plants and adapt their growth/metabolism/…

- Traits involved in Plant/soil Microorganisms interactions, as root exsudates

- Traits involved in Plant-Pathogen interactions, including physical/chemical processes linked to plant/tissue chemical and structural composition, from metabolism to architecture.

- How Social and Economic Sustainabilities will be covered by WP2/WP3: Social/ethical/environmental/physical factors (eg. GMO debate, global warming, weather inclemency and pests)

- Developing an Ecosystem Services vision in CropBooster-P:
Task 1.4 proposed to develop in CropBooster-P an Ecosystem Services based vision of environmental sustainability, allowing to better list traits/functions contributing to sustainability, and better highlight trade-offs…

The T1.4 group has proposed a reduced and manageable list of services, derived from Costanza et al. 1997, see hereafter) and its interest for WP1, and to link WP1 to WP2 & WP3 could be discussed.

From Costanza et al. « The Value of the World's Ecosystem Services and Natural Capital ». Nature 1997:

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#	ECOSYSTEM SERVICE*	ECOSYSTEM FUNCTIONS	EXAMPLES
1	**Gas regulation**	Regulation of atmospheric chemical composition.	CO_2/O_2 balance, O_3 for UVB protection, and SO_x levels.
2	**Climate regulation**	Regulation of global temperature, precipitation, and other biologically mediated climatic processes at global or local levels.	Green-house gas regulation, DMS production affecting cloud formation.
3	**Disturbance regulation**	Capacitance, damping, and integrity of ecosystem response to environmental fluctuations.	Storm protection, flood control, drought recovery, and other aspects of habitat response to environmental variability mainly controlled by vegetation structure.
4	**Water regulation**	Regulation of hydrological flows.	Provisioning of water for agricultural (e.g., irrigation) or industrial (e.g., milling) processes or transportation.
5	**Water supply**	Storage and retention of water.	Provisioning of water by watersheds, reservoirs, and aquifers.
6	**Erosion control and sediment retention**	Retention of soil within an ecosystem.	Prevention of loss of soil by wind, runoff, or other removal processes, storage of silt in lakes and wetlands.
7	**Soil formation**	Soil formation processes.	Weathering of rock and the accumulation of organic material.
8	**Nutrient cycling**	Storage, internal cycling, processing, and acquisition of nutrients.	Nitrogen fixation, N, P, and other elemental or nutrient cycles.
9	**Waste treatment**	Recovery of mobile nutrients and removal or breakdown of excess or xenic nutrients and compounds.	Waste treatment, pollution control, detoxification.
10	**Pollination**	Movement of floral gametes.	Provisioning of pollinators for the reproduction of plant populations.
11	**Biological control**	Trophic-dynamic regulations of populations.	Keystone predator control of prey species, reduction of herbivory by top predators.
12	**Refugia**	Habitat for resident and transient populations.	Nurseries, habitat for migratory species, regional habitats for locally harvested species, or over wintering grounds.
13	**Food production**	That portion of gross primary production extractable as food.	Production of fish, game, crops, nuts, fruits by hunting, gathering, subsistence farming, or fishing.
14	**Raw materials**	That portion of gross primary production extractable as raw materials.	The production of lumber, fuel, or fodder.
15	**Genetic resources**	Sources of unique biological materials and products.	Medicine, products for materials science, genes for resistance to plant pathogens and crop pests, ornamental species (pets and horticultural varieties of plants).
16	**Recreation**	Providing opportunities for recreational activities.	Eco-tourism, sport fishing, and other outdoor recreational activities.
17	**Cultural**	Providing opportunities for non-commercial uses.	Aesthetic, artistic, educational, spiritual, and/or scientific values of ecosystems.

*We include ecosystem "goods" along with ecosystem services.

8. Deliverables

The following WP1 1 Task 1.4- specific deliverables are planned:

Number	Deliverable Title	Lead beneficiary	Type	Dissemination level	Delivery month

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D 1.6	Preparatory documents ready for discussions during workshop with (core) SHG on sustainability improvement	INRA	Report	Public	5
D1.7	Digested outcome and recommendations of the workshop regarding sustainability improvement	INRA	Report	Public	8