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GREENRESILIENT: INNOVATIVE CROPPING SYSTEMS IN ORGANIC GREENHOUSE PRODUCTION

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Abstract: European organic greenhouse production systems are extremely differentiated. The more intensive ones have been object of debates, in the last decade, and a strong request for innovative solutions to reduce the level of intensification comes from the "organic sector". An agroecological approach to organic production in protected conditions can be an option. This paper describes how scientists with competencies in soil science, agronomy, plant pathology, entomology and environmental sustainability assessment interact in the framework of GREENRESILIENT project (CORE Organic Cofund) to implement more resilient cropping systems in protected condition

Introduction: GREENRESILENT, the acronym of "Organic and biodynamic vegetable production in low-energy GREENhouses – sustainable, RESILIENT and innovative food production systems", is a multidisciplinary CORE Organic Cofund (2016) project. Its main objectives are to verify the hypothesis that innovative cropping systems (INN), characterised by the introduction of agroecological practices can be implemented in the main areas of protected organic production in Europe and to demonstrate that less intensive systems of production in organic greenhouse production are viable and sustainable.

Organic farming systems are required to maintain or improve soil fertility and soil health by management tools, which are supposed to preserve an active and diversified biotic community. Unfortunately, the implementation of such agronomic tools in organic greenhouses is considered difficult and not economically sustainable.

In GREENRESILIENT, to significantly reduce the level of intensification, research activities have been implemented in unheated tunnels or low energy greenhouses. A complete redesign of cropping systems has been implemented, based on winter leafy crops (WLC) cultivation (more resistant to low winter temperature) and wider rotation including the cultivation

of agroecological service crops (ASC). GREENRESILIENT involves twelve research groups from eight European Countries. Experimental sites are located in Belgium, Denmark, France, Italy and Switzerland. The project has five interacting work packages (WPs) schematically described, as follows. The entire project is under scientific coordination of WP1.

Material and methods:

WP2 – RESILIENT CROPPING SYSTEMS

At the experimental sites a minimum of two systems are compared; a Business As Usual (BAU) and an INN. The BAU and INN systems vary between countries and reflect common practice in the individual country. In general, the BAU systems are characterized by low biological diversity, low input of organic matter, high pest and disease control by wide spectrum products approved for organic plant production and high energy input for heating. A comparison of production factors investigated in each country is shown in Table 1.

All systems use tomato as the main crop and all INN systems grow one or more WLCs. In the Mediterranean countries rocket, lettuce, spinach and lamb lettuce are grown and in the Central and Northern Europe these crops are supplemented with Swiss chard, winter purslane and Asian greens. In 2018/2019, three crop cycles were introduced in one year in the Danish INN system. A short tomato crop intercropped with peas (May – Oct.) followed by WLC's (Oct. – April) and a crop of lettuce (April – May). In France, Switzerland and Belgium, crop diversity during both winter and summer was introduced and in Belgium ASC's were grown between crops. Italy is having two INN systems: a biodynamic and an agroecological one differentiating between the use of biodynamic preparations and type of compost.

Results: WP3 – CROP YIELD, NUTRIENTS AVAILABILITY AND SOIL FERTILITY ASSESSMENT

Large flows of nutrients and organic matter occur in organic greenhouses. GREENRESILIENT hypothesizes that crop diversification and alternative fertilization strategies in INN, compared to BAU result in enhanced nutrient cycling and utilization and in improved overall soil quality. N dynamics get special attention, as plant available N is decisive for crop performance.

Nutrient cycling and utilization

Increased nutrient cycling in INN is attempted by (i) more diversified crop rotations including mixed cropping and ASC cultivation, (ii) reduced tillage practices, (iii) green manuring including imported ASC biomass and (iv) plant based fertilization products, lowering the need for off-farm fertilizer inputs. GREENRESILIENT investigates if INN practices result in more balanced nutrient supply lowering the risk of nutrient surpluses, especially regarding phosphorous. Nutrient, crop and biomass inputs and outputs are determined to assess nutrient flows in the two systems and evaluate nutrient balances. Short term N dynamics are assessed to find out if INN practices result in sufficient or even improved synchronization of soil mineral N with crop need.

Soil fertility building

The crop and soil management practices applied in INN are hypothesized to build up soil fertility due to enhanced organic matter input and biomass production levels. During the full experimental period, C input from ASC biomass, crop residues and fertilization products is assessed in both INN and BAU.

Discussion: WP4 – SOIL HEALTH AND FUNCTIONAL BIODIVERSITY

Soil health and biodiversity are fundamental features for both organic production systems and an agroecological approach. Well-studied in various open field ecosystems, these two phenomena have been much less investigated in organic greenhouse ecosystems. As cropping system parameters (crop choice, crop rotation intensity) as well as environmental factors (temperature, precipitation/irrigation, humidity) used in organic greenhouse horticulture vary substantially from the ones prevailing under open field conditions, dynamics in soil biodiversity and health cannot be translated from open field conditions.

Soil biodiversity is a very complex phenomenon, but the introduction of recently developed technology, such as next generation sequencing and related statistical tools, in combination with traditional methods, allows the differentiation between morphological biodiversity, taxonomic biodiversity (*species biodiversity*), ecological biodiversity (variations within the ecosystem) and functional biodiversity (measure of the number of functionally disparate species within a population based on feeding preferences or mechanisms, motility and predation).

Regarding soil health and functional biodiversity, particular attention is given to species richness and species diversity amongst soil microorganisms, nematodes, arthropods, weed and plant pathogens.

Soil health and soil disease suppressiveness are two factors describing the output of a well functioning ecosystem. Like soil biodiversity, soil health is a very complex phenomenon and the following bioindicators have been used in GREENRESILIENT:

i. soil microbial parameters (activity, biomass, activity of various enzymes related to degradation of organic matter and/or nutrient cycling)

ii. nematode community structure (including bacterio-, fungi-, herbi-, omnivores as well as predators)

iii. soil arthropods structure

For soil suppressiveness, two types of bioassays will be conducted in GreenResilient. The impact of BAUs and INNs after two years of rotation is studied with respect to *Rhizoctonia solani* and *Pythium aphanidermatum* using tomato as model crop and the abundance of fungal endophytes colonizing soil arthropods (fungal entomopathogens) is surveyed.

However, soil health is strongly interlinked with the abiotic and biotic soil factors, so collected data from different WPs will be analysed using multivariate statistical approaches to identify decisive factors discriminating soil health-promoting and counteracting strategies.

WP5 - COMMUNICATION, ACTORS' INVOLVEMENT AND SUSTAINABILITY ASSESSMENT

All five experimental sites will undergo an environmental assessment, using a Life Cycle Assessment (LCA) to compare the environmental sustainability of INN and BAU systems.

Project activities and results are communicated in several languages to a wide range of stakeholders using a variety of channels (e.g., experimental site visits, various online platforms, leaflets and videos). Interactions with stakeholders, e.g., through events, also provides valuable feedback. A special focus is placed on food citizenship and two-way communication with consumers through consumer-targeted leaflets, media and events. For example, events where consumers learn about uncommon crops that are suitable for winter greenhouse production in their regions and provide feedback about their awareness and willingness to purchase the crops.

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Table 1 Factors studied in BAU and INN systems at experimental sites. Symbols: (+) low, (++) medium and (+++) high level.

Image:

Production factor	Italy		France		Belgium		Switzerland		Denmark	
	BAU	INN	BAU	INN	BAU	INN	BAU	INN	BAU	INN
ASC/IC	+	+++	+	+++	+	+++	+	++	+	++
Crop diversity	++	++	+	+++	+	+++	+	+++	+	+++
Soil tillage	++	++	+++	+++	++	++	+++	+++	++	++
Organic matter	+	+++	+	+++	+	+++	+	++	no	+
Pest control	++	+	++	++	++	++	+++	+	++	++
Disease control	+++	+++	++	++	++	++	+++	+	++	++
Flower strips	no	no	no	yes	no	yes	no	yes	no	yes
Solarization	yes	no	no	no	no	no	no	no	no	no
Biodynamic prep	no	yes	no	no	no	no	no	no	no	no
Heating	no	no	no	no	no	no	high	low	high	low

Disclosure of Interest: None Declared

Keywords: cropping system redesign, functional biodiversity, life cycle assessment, nutrient availability