EIP-AGRI Focus Group – Circular horticulture

Mini-paper – *Awareness raising and transfer of knowledge and technology in circular horticulture*

Ellen Beerling, Els Berckmoes, Rafaela Cáceres, Irene Väninnen, Javier Garcia, Fransisco Egea Gonzalez

Introduction

When speaking of circular economy (CE) in protected horticulture, recycling of water and nutrients is by far the most common CE practice. However, substantial regional differences occur in the level of water and nutrient recirculation. In the Netherlands and Flanders, recirculation of water and nutrients is a common practice in protected soilless cultivation systems; these systems are, considered closed systems. Even so, 5-10% of the nutrient solution is discharged yearly (Beerling et al., 2013, Berckmoes et al., 2013). In Almeria, Spain, on the other hand, the area of soilless crops decreased from around 20% of the growing area in 1999-2000 to 9.8% in 2012-2013, as their beneficial effects were reportedly considered low by growers (Garcia Garcia, 2016). As a consequence, recirculation of water and nutrients is implemented by a minority of the growers in the Almerian region.

Nevertheless, it is expected that the need for further CE practices will increase in the future. Water scarcity has become an important issue in several European regions, making, for example, the use of treated urban waste water an attractive option. In 2016, a survey was carried out in the framework of the European project FERTINNOWA. The survey revealed that less than 2 % of 371 surveyed farms all over Europe implemented the disinfected grey water source for irrigation purposes (Lechevallier et al., 2018). This is very little compared to Israel where 60% of the water applied for irrigation is treated wastewater (Vilt, 2018). Nevertheless, early adopters of disinfected urban wastewater can be found all over Europe.

The example above shows that CE in protected horticulture is promising but will require a mind shift of the farmers. One of the key issues is that farmers will have to rethink their complete system and must have an eye for the bigger picture. In the bigger picture of CE, greenhouses are like plant cells: their chemistry, structure, and functions become entirely understandable only when seen as parts of the whole plant. Cells must communicate with each other to do their job in keeping up the integrity of the whole plant. Likewise, in CE, greenhouses connect more widely with other activities in the society. In so doing, they increase both their own and the society's ecological sustainability and reduce their costs.

An inspiring example can be found in Kruishoutem, Belgium, where a tomato greenhouse, Tomato Masters, and a fish farm, Aqua4C, joined forces to cluster their nutrient and energy loops. Nowadays, Aqua4C implements the excess of heat and electricity produced by the cogeneration unit of Tomato Masters. Although this excess is limited, it suffices to keep the fish water at the desired temperature of 27 °C. In the future, a two-way exchange will be established between both companies as Tomato Masters will implement the nutrient wastewater of Aqua4C as a new low-cost nutrient source for the tomato crops. Final experiments are carried out at a Flemish research station PCG to guarantee a safe implementation of this water and nutrient source in the tomato crop.

This mini-paper focusses on the elements to foster transfer and uptake of technologies and practices in the field of circular horticulture as set from the author's professional experiences.

funded by European Commission

Raise awareness

In general, awareness raising and information transfer are crucial to encourage uptake of knowledge and technologies. These actions should address the different actors (farmers, advisors, technology suppliers, authorities, policymakers, market, consumers) in the horticultural chain and focus on the importance and value of circular horticulture, both at the micro (farm) and macro (regional, national, European) level. For this, mechanisms and policies are needed providing different tools adapted to the needs of the different actors: information, training, and – fundamentally – reasons why to shift towards more sustainable horticulture. The importance of awareness raising at the level of the different actors is illustrated for some principal actors:

At the farm level:

Farmers play a central role in the knowledge and practice uptake process as at the end; they will be the actors implementing both knowledge and technologies.
Firstly, growers should be aware of the impact and benefits that circular horticulture might imply for their farm in the first place, but also for the region. Today, growers are still not fully aware of the current condition of their region and the impact the farm's practices might have. As an example, the FERTINNOWA survey showed that growers' awareness regarding the current status of the local water quality differs significantly amongst the different European Member States. For example, 13% of the respondents were not aware if their farms were located in a zone affected by environmental constraints and if there were any restriction to be taken into account (Lechevallier et al., 2018).

When informing growers, it is important to stress that "all bits make one big." If all farmers contribute, a more prominent impact can be achieved.

At the societies level:

Awareness should also be promoted in society, in general, because the potential consumers of environmentally friendly products are the global society. The technology, techniques or practices should fulfil a real need for the growers or the consumers, but nowadays it is not easy. Urban citizens are not necessarily aware of the environmental challenges linked to agriculture and how to face them. Therefore, awareness should be promoted among both, growers and society. Awareness raising at the societal level focus on education (children, young people) and the knowledge transmission from old to young generations. Yet, in many European countries, there is still a generation that grew up in the countryside that could contribute to the awareness of younger generations. Circularity is based on ancestral principles that were thoroughly widespread in agriculture only some decades ago.

On the other hand, some practices would promote circularity in urban environments. An example is the urban gardens. These small, but practical, activities are increasing in cities and could be an excellent opportunity to increase awareness in circular horticulture.
Another example is the awareness of organic farming products in cities. There are many consumer cooperatives in which end-users, not only have the opportunity to order organic food but also they have the opportunity to be trained in environmentally friendly agriculture. Sometimes, these cooperatives arrange visits to the countryside where organic products are produced and keep the end-users in direct touch with growers. These kind of initiatives are increasing in European cities.

At the research, educational and governmental levels:

Universities, research centers, and other stakeholders should support to increase the environmental awareness of the global population. Moreover, governments, who have a global vision of the earth problems, have to support them to do it.

Finding the triggers

funded by European Commission

Once farmers are aware of the importance and impact of circular horticulture, there is a need for triggers to lower the barrier that keeps them from actually implementing the practices and technologies related to circular horticulture. Different triggers would boost circularity in horticulture both at the farms level as beyond:

Triggers at the farms level:

In general, specific triggers are identified that encourage technology uptake at the farms level. The most critical triggers identified at the farms level are listed below:

- The solutions **should be affordable and reliable** to justify and motivate their uptake in the economically challenged horticultural sector. Running a greenhouse enterprise is all about reducing risks, as the entire business model depends on the productivity of the crop. So reliability is required on quality, quantity and time availability, or back-up should be present.
- **Availability of economic, environmental and technical studies** that would support the implementations. Societally, environmental issues are the main ones that presuppose circularity; and the data on water, materials scarcity should be provided to the growers to raise their awareness.
- The need **for showcase and demonstration**. Growers need reliable proofs of the suitability of specific technologies to adapt them. So, at the regional level, an extra-effort between administration and companies should be done to show the techniques and practices that would increase circularity.
- **Availability of technical support** and the knowledge that demonstrate the feasibility of the proposed techniques or technologies in the particular case of each company. Therefore, the technological innovations can be adapted to the local/particular circumstances and scaled-up.
- Sometimes, the take up of elements of circularity in agro-systems means to **adapt to the particular production model of the company.** Such tailoring to local and particular circumstances of companies is necessary but requires both time and investments.
- The **technical advisers of farms** are key actors that would translate the advantages of the alternative solution to the grower. These actors should be trained first, and a joint scheduled program should be designed for the growers from these advisors and promotors of the technology.

Drivers outside the farm:

- Other drives could be the **policies from the administration** (national governments, municipalities, regional government) that would fund or subsidy part of the first implementations at full scale and others (e.g., promoting favorable fiscal policies).
- The implementation of circular solutions should ensure **the follow-up of the system**. Therefore, after-sale-service should be offered by developers.
- **Market and consumers.** Growers are linked with markets through the products and services they supply to consumers to fulfil the latter's' private and societal needs. Actions devoted to increasing the awareness of the general population will increase the market demand for products produced through sustainable methods. Awareness among consumers on the benefits of circularity can contribute to their willingness to pay more for environmentally friendly products. Such promotion can be done directly by growers or by associations devoted to market the products in international or national markets. Sometimes the adoption of new practices could even open new markets and make adoption of circularity technologies more attractive for businesses
- Implementation of the solutions in **key companies**. Horticulture sector is spread in specific areas, where different companies are working, sometimes in competition. Usually, there are "key" companies that are references to the other ones, and the practices they do would be implemented in the other companies. These companies could implement and, in this way, they can be considered as early-adopters paving the way for larger user groups to adopt the technology.

funded by European Commission

- A key trigger that should be assessed according to the profitability of the business sectors is pushing through **legal constraints**. There are some good examples in other fields in which laws have helped to boost specific policies.
- The implementation of circularity will be boosted when the suppliers of the new items (waste, sources of energy, investment resources) would be prepared for **supplying the needed items**.
- Customer Interconnection Tools (CIT)-based tools are necessary to boost knowledge and technology transfer for circular horticulture, ex:
  A database containing relevant information from regional, national and European projects dealing with circularity, would be necessary. This database would contain available knowledge, technology, and processes either at the laboratory, pilot, demonstration or industrial scales. The content of this database should be available to technical advisors to be aware on the advances in the fields of sustainability and efficiency of the production steps, but also to other actors of the value chain, including logistics, packaging, and waste management. At these stages, the information on the database would be useful to entrepreneurs, which might start with new business focused on the use and valorization of waste from the current value chains.
- A database builds on a Geographic Information System containing a detailed analysis of the current agricultural practices including the whole value chain in different locations, highlighting, for example, the nature, frequency and amount of biomass generated. This information should be obtained from technical advisors and farmers, allowing a diagnosis of the level of sustainability and efficiency of the current value chains, benchmarking, as well as gaps concerning knowledge and technology.
- By matching both databases, a package of likely solutions for circularity, and new business models would be obtained at different stages: the primary production would identify solutions for farmers to be more efficient, waste would be reduced along the value chain, and risks for the entrepreneur that start with new business would be minimized.
- A public fund is necessary to boost new business models related to the circular economy, for example, supporting entrepreneur to scale-up knowledge and technology to commercial exploitation, start-up creations, and initial investments.
- Boosting public procurement-public purchasing of innovative technology facilitating the access of farmers and other value chains actors to expensive infrastructures, for example, in the field of energy and CIT, which can be used by the whole stakeholders.
- Finally, the creation of web platforms, networks, and the organization of specific events boosting the dissemination of circularity-related actions to promote the products generated with circular principles in the markets, boosting the consumer's demands.

Bottom-up approach and business plans supporting technology and best practices uptake

If one wants to support the uptake of innovations and best practices of circular horticulture by farmers, it is vital to understand what drives growers to implement technologies and practices. For example, the FERTINNOWA survey showed that growers tend to implement technologies that are cost efficient, do not decrease the yield or quality of the crop, require a minimum of maintenance, etc. (Lechevallier et al., 2018).

The ways to evolve towards more circular horticultural practices might also differ among farmers. Figure 1 shows the different practices that respondents were planning to implement in order to limit the effluent discharge of their farms. Respondents of the North Western and Central eastern regions of Europe were mainly considering the implementation or improvement of drain water recycling. In the Mediterranean region, 38% of the respondents were planning to collect drain water while only 17% were willing to recycle this water. In the Northwestern region, 10% (other) of the respondents were thinking about implementing end-of-pipe solutions to remove nutrients from the effluents before discharging the effluent.

funded by European Commission

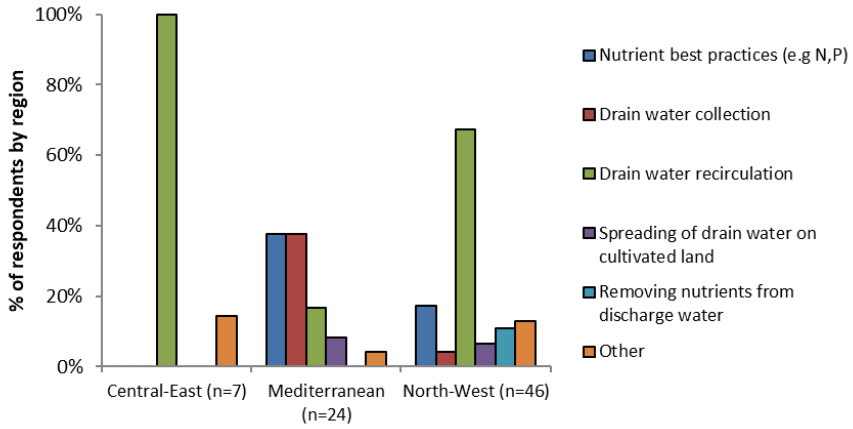

Figure 1 Practices to be implemented by respondents by regions to limit effluent discharge (Lechevallier et al., 2018)

Besides the willingness of the farmers to implement technology at their farm, a clear business plan is required. Although farmers opted for few categories like drain water recycling, drain water collection, nutrient removal/recovery from discharged water, … the technologies and practices to meet these goals in a cost efficient way might differ strongly. In many cases, there is no one-suite-all scenario. A successful transfer of technology, to the farmers' level, implies that the technology or practices will need to meet a set of criteria as important for the specific region of the farm. This is illustrated based on the Zunurec project (Table1.). In this Flemish bottom-up project, a technology supplier, plant nursery and practice center collaborate to develop an onsite installation to purify the produced nutrient rich waste water at the nursery plant and to recover the nutrients present in this waste water stream, as well as the purified water.
From the start, the owner of the nursery has listed 3 criteria that will have to be met:

1. The regenerated water and fertilisers will have to be safe for the nursery plants
2. It must be guaranteed that the environmental legislation is met during the discrepancy period of the installation as the excess of purified water will have to be discharged.
3. The total cost per m³ treated discharged water has to be lower compared to the current cost of off-site treatment (currently treatment costs may rise to 45€-60€ per m³).

Examples of bottom-up and multi-actor initiatives

In recent years the EU Commission and in particular EIP-Agri is working to stimulate the use of an interactive innovation model with the aim to bridge the existing gap between research and implementation at the farms level. Knowledge exchange among the different key players like farmers, advisers, researchers, technology suppliers and other actors like policymakers is acknowledged as a way to generate new insights and ideas in the 2014-2020 programme period.
This approach has found its way to the national and regional research programmes as well. Such a multiactor approach helps farmers to see the bigger picture and adopt the mind shift that is needed to encourage the uptake of circular practices.

One example of a multi-actor project is the CLEANLEACH® project, which after its execution has become a registered system (Marfà et al., 2016; Cáceres et al., 2016). The idea of CLEANLEACH® was initially developed by IRTA (research center), although the execution of the project was carried out in close collaboration with other companies focused on green architecture (Buresinnova) and bioengineering (Naturalea and Salix). IRTA holds pilot plants of the two techniques that the CLEANLEACH® system includes (horizontal sand filter and constructed wetland). Two demonstration sites were implemented at full scale at the United Kingdom (constructed in a Salix nursery) and Spain (Vivers Sala Graupera, Sant Andreu de Llavaneres, Barcelona) (Figure 2). Vivers Sala Graupera is an important nursery dealing with the production of plants for eco-gardening that is being engaged with

funded by European Commission

the idea of the project to facilitate the dissemination of the new techniques among the sector. On the other hand, during the project development, other sectors dealing with waste were involved in promoting the circularity not only within the horticulture sector.

Figure 2 View of the constructed wetland, one of the techniques demonstrated in the CLEANLEACH® system at the Sala Graupera nursery (Sant Andreu de Llavaneres, Barcelona-Spain).

At the European level, the first bottom-up and multi-actor projects were funded in 2015. A non-exhaustive list of some European initiatives regarding circular horticulture is included in Table 1.

funded by European Commission

Table 1 Some examples of bottom-up and multi-actor projects and initiatives in the field of circular horticulture

Project (funding/type)	Content	Link to circular horticulture	Actors involved	Implementation stage
Water and nutrient recycling				
AquaReUse *Funded by the local water authority, EFRO, Provincial Government & Sectoral organisation* http://www.aquareuse.nl/	AquaReUse focuses on the production of high quality irrigation water from discharge water. Nutrients are removed by a helophyte filter; clean water is produced with reverse osmosis.	Wastewater is recycled to clean irrigation water for plant nurseries.	Local water government, practice centres/university, engineers, growers, technology suppliers	In 2017 deliverance of clean irrigation water to plant nurseries started.
Cleanleach *An eco-innovation initiative of the EU* http://www.cleanleach.eu	Cleanleach focuses on the use and treatment of leachates produced in nurseries. Leachates are collected using a horizontal sand filter located under the culture, and the treatment of the leachates (designed to get rid of nitrates) are carried out by constructed wetlands.	Improved recirculation of drain water of plant nurseries. Plant pathogen propagules can be retained in the sand filter (Prenafeta-Boldú et al., 2017), the fact that can boost recirculation of leachates. Constructed wetlands purify the leachates that can not be recirculated any more	Research centre (IRTA), plant nurseries, experts in green architecture and bioengineering	The technology is implemented at a nursery demonstration site. No further implementation yet due to the economic crisis. Technology has been taken up by the FERTINNOWA project to treat leachates of a greenhouse crop in Almeria.
FERTINNOWA *H2020 CSA action – thematic network* www.FERTINNOWA.com	Thematic network focusing on the collection, evaluation, exchange, and showcase of technologies and best practices related to efficient water and nutrient use in fertigated crops.	Particular focus on technologies to reduce the environmental impact of fertigation.	Practice centres, university, technology suppliers, advisors External board: growers, authorities, consumer organisations, NGO's	Showcases are set up at the farms level: • Cleanleach in Almeria greenhouse • Ephos in Flemish azalea greenhouse to recover N and P from discharged water • Sodium recovery unit (SRU) in Belgian research station…
Rich Water *H2020 Fast track to innovation* *richwater.eu*	RichWater solution is combining low-cost and energy efficient MBR treatment, a	Focus on implementation of reclaimed water.	Technology suppliers and developers, research institutes. Growers, authorities,	Showcases are set up at the farms level.

funded by European Commission

	module for mixing the optimal combination of clear and reclaimed water, and an advanced monitoring /control module including soil sensors to guarantee demand-driven and pathogen-free fertigation.		associations, … are involved in workshops, events, ….	
Zunurec Circular Flanders (Flemish initiative)	This project focus on closing the nutrient and water cycle of a Flemish plant nursery.	Aim to recover nutrients and water from the discharged water stream and implement them at the nursery site.	Technology supplier, plant nursery, practice centre.	Investigation – demonstration stage.
Project (funding/type)	**Content**	**Link to circular horticulture**	**Actors involved**	**Implementation stage**
Substrates				
The new circular economy in horticultural production – Arvobio (Biovalue) http://www.hamk.fi/tyoelamalle/hankkeet/puutarhatuotannon-uusi-kiertotalous/Sivut/default.aspx	This initiative focusses on producing added value and new businesses through innovations that reduce waste and increase use of side streams in horticulture.	Greenhouses: how to utilize plant biomass for different purposes; specific focus is on tomato biomass and growing media.	A university of applied sciences in horticulture, a research institution, advisors, greenhouse and field vegetable producers	Awareness raising, showcases, company visits, information spreading through various media, research.

Supporting transfer

Language

One of the main barriers to the development of a mutual learning community is related to the use of different languages, tools, and standards by the different actors involved in it. When one would like to reach the end-user in a European initiative, translation of the outcomes and key messages in the farmer's mother language is critical. Still, although researchers and the end-users might speak the same language, the message brought by the researcher might not wholly be taken up by the grower. This means that the message provided towards the end-users have to be easily understandable and to contain all essential elements (cfr. Section on triggers). The practice abstract database of EIP-Agri is a first large scale European initiative to support this translation of research outcomes towards the end-users widely. Practice abstracts are short summaries of technologies or project outcomes containing practical information for the farmer.

Channels:

Growers are busy people and seldom have time to read and digest long articles. Often the text is not the best way to distribute information to them. Growers like to listen, learn through discussion, see things in practice, learn from each other in practical situations (farmer-to-farmer extension), pose

funded by European Commission

questions to which they get answers immediately. Current media and internet technologies offer many channels and methods to deliver information, even in an interactive way:

- Practice abstracts that have pictures and even videos embedded in them
- YouTube movies in the form of visual fact sheets, created in practical conditions for growers who are pioneers in up taking circular technologies
- Live webinars with the possibility to ask questions on the spot
- Animated videos that illustrate principles and practices
- Short articles that go straight to the point, published in growers magazines and on-line
- Live feeds through Facebook that will be stored for later use

Facilitators and advisors play a key role in both preparing and delivering information through different channels, but also in personally organizing cross visits to greenhouse companies pioneering in circularity technologies. Cross visits used in the AgriSpin project were deemed an efficient way of learning about innovations in agriculture (Wielinga et al., 2016). The type of support given to practitioners to encourage uptake of circular practices must be planned according to the phase of innovation. The initial phase assumes innovative, sometimes not easily anticipated support services such as network building and support to the innovator. Whereas in the last phases, there is a need for more conventional services (e.g., training, advice, credit) at all levels (farm level, value chain, territory).

Online monitoring of technologies performance or practices impact

The use of online monitoring tools and app's for mobiles will, in a short future, show the performance or impact of the systems implemented for improving the circularity. An example is the Web app created for demonstrating the elimination of nitrates in leachates produced in nurseries (Cáceres et al., 2017).

Key messages

Company level economic sustainability is by far the most critical driver of organizing production in greenhouses: without economic sustainability, there is no production. On top of this, society nowadays requires ecolocigal and social sustainability. At the company and product levels, such demands are addressed, for example, by carbon footprint calculators. They concretize the need of reducing airborne emissions for the benefit of whole humanity. Thus they show how greenhouse production is linked with the bigger, global picture. This is an important step towards viewing one's own business through a different kind of logic.

For a greenhouse company, societal demands for increased environmental performance should preferably bring along better cost-effectiveness and competitiveness. They are usually achieved through better technological efficiency and effectiveness. Cost-reductions are always an excellent incentive for uptake of new technologies in sectors that have thin economic margins.

However, cost reductions are just the beginning of the road towards circular greenhouse production. New business models are also needed. A business model reveals the mental models that an entrepreneur has in use in his or her mind to get value out of what he or she is doing. A business model reflects the organizational and personal values that influence how economic value is achieved by the company. Business models – how the company creates value – should guide the choice of technological solutions and not the other way round. This may pose a challenge not only to growers but also to technologically oriented advisors and facilitators who are supposed to support growers in change.
In a circular economy, staying at the company level may suffice to begin with when aiming at increased technological and material efficiency of the production process. However, circular economy inevitably brings along the whole value chain. How is a grower able to get value from, for example, leaves and stems of tomato plants unless it finds some party who needs them as raw material? In the past, growers may have taken such biomass to their fields or a forest lot or composted them: they

funded by European Commission

were working in the domain of their farm. If they find another business that needs their by-products, they may get more value from the by-products. Their business model, the logic for making money, must change, and along with it changes the value chain and the mental models of growers and other members of the value chain.

Thus technological transfer in the circular economy is not just about technologies. It is about communicating the whole big picture:

1. Why must greenhouse production become more circular? What is the overall purpose of the circular economy for our society? What benefits does it bring to individual greenhouse businesses? Closed material loops to save resources also for future generations and guarantee that individual businesses can continue their activities also in the future. Understand your dependencies on natural resources, but also the opportunities your company's wastes can bring to you.
2. What is the scale through which a greenhouse business must think its activities and how they are connected with other activities in the society? Value chain. Your business model must reflect this mutual dependency and its opportunities. You make money through collaboration with the value chain.
3. What are the principles of circular economy and how are can they bring benefits to greenhouse businesses? Close material loops, i.e., stop filling landfills and keep stuff moving in the loops between different activiets for as long as possible. Collaborate with your value chain. Maximize value production, not only from end products but also from by-products and materials you regarded as waste before. Use renewable energy sources. All this should lead to positive ecological footprints, strong sustainability and resources that future generations also can benefit from, not just us.
4. What are the criteria that business models, production processes and products should fulfill to be regarded as circular? These criteria are listed, e.g., by Camacho-Otero & Ortonez (2017)
5. Moreover, finally: how can technological solutions help you as a grower to achieve circularity in your own business? How can they contribute to reducing waste and production costs and increasing the value that you get from your busines? To follow whether you are reaching your goals of circularity? To communicate your new business model to your customers? To engage your staff in the change towards circularity?

Need for showcase and demonstration

As stated in a previous section of this document (raise awareness/finding the triggers), any change in the procedure of a particular system should be validated under field conditions and should include different perspectives including the technological, practical, socio-economic but as well the legal perspective. It is necessary to showcase the results to make them visible at full-scale conditions.

Growers –as other company holders- need reliable proofs of the suitability of specific technologies to adapt them. As an example, the Rich Water project organised a first workshop during which farmers expressed their interests in alternatives for their conventional water resources since there is a real risk of water drought (Casiellis R., 2018). However, there are still concerns about the safety of treated wastewater for the crops and the impacts on yield or organoleptic properties of the crops. Thus, the second workshop will focus on scientific results of the experiments carried out with tomatoes, mangos, and avocados at the experimental site.

Furthermore, these demonstrations and showcases should pay attention to the business plan and the possibilities to adapt CE technologies to the farm's specific situation as there is no one-fits-all technology when it comes to technologies in the horticultural sector. Take for example aquaponics that combines fish and plant production. Production of fish in fish tanks indoors can be a considerable energy-consumer as the water often needs to be heated. However, in the case of Tomato Masters and Aqua4C, this energy demand could be covered by clustering both companies.

funded by European Commission

Therefore, to boost the implementation of new technologies, methods or tools to increase the circularity of the horticultural systems, some examples should be constructed to facilitate visits, seminars. Also, demonstration sites could be a key platform to adjust the systems to other technical or environmental circumstances.

Proposal for potential operational groups

- OP1. Operational groups focusing on the training-the-trainers and in a second phase training the growers.
- OP2. An operational group for increasing and tailoring ancestral practices in horticulture. The local and ancestral practices would be known, spread and probably most of them could be tailored to the current situation.
- OP3. Operational groups for adapting existing new technologies to cope with horticulture challenges. Several available techniques or technologies could be gathered (website: data base or videos in different languages). Based on this database, OP groups would apply for introducing these technologies to their farms.
- OP4. Operational groups focusing on supporting circularity by linking farmers and suppliers to other sectors such as urban waste water plants, plastic, textile, metallurgical industries, energy providers, waste treatments plants (heat),... An example can be found in the collaboration between Heinz and Ford (**https://www.telegraph.co.uk/business/successful-partnerships/heinz-ford-tomato-fibre-bioplastic/**).
- OP5. An operational group of distributors and producers to put value in the circularity in agriculture, an example to reward farmers who demonstrate a high involvement in the circularity.
- OP6. Circularity in organic horticulture.
- OP7. Circularity in urban gardens: common services (composting, water supply and quality, leachate treatment)

Proposals for (research) needs from practice

- NEED 1. Database and web App on new technologies, techniques, and practices for implementing circular horticulture. The focus should as well lay on examples of implemented technologies at the farm's levels. All content should be translated into the EU languages to facilitate the transfer.
- NEED 2. There is a general need to map existing requests and offers as reported by the different actors involved. When a grower, for example, needs energy, water, nutrients, … this need could be linked to actors that might offer these inputs. In this way, initiatives like the one of Tomato Masters and Aqua4C could be supported.
- NEED 3. Demonstration of successful technologies, techniques or practices: scientific, environmental and technical indicators.
- NEED 4. In many cases, the potential of a technology depends on the specific situation of the company. Business plan structures should be made available to check technologies potential at the farms level.
- NEED 5. There is a (research) need for new equipment and/or technologies fostering circularity, like:
    - Biodegradable materials like ropes, clips, … that preserve their strength and quality during the growing season.
    - Technologies to recover nutrients and water
    - sensors, decision support tools, ….
- NEED 6. Boosting the "circular-product" demand similar to the "km0 products". Therefore, advertising campaigns should be done to the reach both the grower's society and the general society. Probably this kind of action should be done merging social, technical, environmental and economic views.

funded by European Commission

Recommendations for further development

- REC 1. Training on the transfer of technology and knowledge for developers at the regional level. Dealing with horticulture, developers of products, techniques, or technologies should have the objective of put their achievements in the market. Sometimes, the project proposals have scarce inputs on this regard. So, the objective would be focused on transfer itself.
- REC 2. Development of a database providing offers and request in the field of circularity. This database should focus on the different actors (farmers, suppliers, ….) but as well at the different levels (regional to national, …) to foster initiatives. An example can be found on **http://vlaanderen-circulair.be/nl/doeners-in-vlaanderen**
- REC 3. Create an organization at European level that helps to unify criteria of circularity and establish guidelines that help to achieve it.

Conclusions

Implementation of circular economy in protected horticulture is promising. Today, all over Europe, inspiring examples of early adopters in the field of circular horticulture can be found. However, to foster further uptake of technologies and knowledge related to circular horticulture, a mind shift of the farmers is needed. Circular horticulture is not just about technologies. It requires that farmers rethink their complete system and have an eye for their farms but as well for the bigger picture.

The different actors such as farmers, advisors, technology suppliers, authorities, and policymakers, but as well consumers can play a vital role in this process.

Farmers play a crucial role in the knowledge and practice uptake process as at the end; they will be the actors implementing the knowledge and technologies. Raising grower's awareness for the potential of circular horticulture is a vital step. Initiatives taken to raise grower's awareness should start from the grower's point of view, answering questions like: "Why must greenhouse production become more circular? What benefits does it bring to individual greenhouse businesses?".
To better understand the bigger picture, existing initiatives, like for example the Aqua4C and Tomato Masters should be showcased and demonstrated as they might work inspiring for the growers. National or local databases, mapping the current offers and requests may foster future initiatives to close the loops. Technologies should be showcased and demonstrated for longer terms as growers need reliable proofs of the suitability of certain technologies to adapt them. In general, there is a need for new business models as in many cases; there is no one-suits-all scenario. In case existing technologies are insufficient to meet the grower's or other actors' needs or to provide a positive business plan, further research initiatives should be taken. These initiatives, however, should focus on the grower's needs and set criteria to foster uptake at the farms level.

In recent years, the EU commission and EIP-Agri have undertaken initiatives to bridge the existing gaps between research and implementation at the farms level. Bottom-up approach and multi-actor involvement are two pillars of the 2014-2020 research programme period. Recently, many multi-actor and bottom-up initiatives have been initiated, and the first results are very promising. Projects such as, CLEANLEACH®, Rich Water, FERTINNOWA, … are providing or transferring technologies that are ready for uptake by the farmers. Broad dissemination of these project outcomes is needed through several channels and should be in the grower's native language.

Also, society can play a vital role to support the transfer of both knowledge and technologies in circular horticulture. Today, urban citizens are not necessarily aware of the environmental challenges linked to agriculture and how to face them. Actions devoted to increasing the awareness of the general population should be set up to increase the market demand for products produced through sustainable methods.

funded by European Commission

References

- Beerling, E.A.M., Blok, C., van der Maas, van der A.A. & van Os, E.A.(2014). Closing the water and nutrient cycles in soilless cultivation systems. *Acta Horticulturae*, 1034, 49-55.
- Berckmoes, E., Van Mechelen, M., Mechant, E., Dierick, M., Vandewoestijne, E., Decombel, A. & Verdonck, S. (2013). Quantification of nutrient rich waste water flows in soilless greenhouse cultivations. *Proceedings of the NUTRIHORT: Nutrient management, innovative techniques and nutrient legislation in intensive horticulture for an improved water quality conference*. Ghent, Belgium, 16-18 September 2013. Pp 59-64.
- Cáceres, R., Narváez, L., Antón, A., Puerta, A., Marfà, O. 2016. La economía circular llega al sector viverista y al gremio de la arquitectura vegetal 2. Flormarket Global 82:46-51.
- Cáceres, R., Pol, E., Narváez, L., Puerta, A., Marfà, O. 2017. Web app for real-time monitoring of the performance of constructed wetlands treating horticultural leachates. Agricultural Water Management 183:177-185.
- Faure, G., Knierim, A., Koutsouris, A., Ndah, H. T., Audouin, S., Zarokosta, E. & Heanue, K. (2017). How to strengthen innovation support services in European rural areas: lessons learnt from AgriSpin. European Seminar on Extension and Education (ESEE 2017). 23, Chania, 4 July 2017/7 July 2017.
- Garcia Garcia, M.C., Cespedes Lùopez, A.J., Pérez Parra, J.J.& Minguez, P.L.(2016) El sistema de producción hortícola protegido de la provincia de Almería , IFAPA
- Lechevalier, E., Stavridou, E., Granell-Ruiz, R., Key, G.& Berckmoes, E. (2018) Benchmark Survey. Final version as of 14.05.2018 of Deliverable 3.3 of the Horizon 2020 project FERTINNOWA. EC Grant agreement no: 689687, **http://www.fertinnowa.com/wp-content/uploads/2018/05/Benchmark-report.pdf**
- Marfà, O., Narváez, L., Antón, A., Puerta, A., Cáceres, R. 2016. La economía circular llega al sector viverístico y al gremio de la arquitectura vegetal-1. FLORMARKET Global 81:30-35.
- Prenafeta-Boldú, F.X., Trillas, I., Viñas, M., Guivernau, M., Cáceres, R., Marfà, O. 2017. Effectiveness of a full-scale horizontal slow sand filter for controlling phytopathogens in recirculating hydroponics: from microbial isolation to full microbiome assessment. Science of the Total Environment 599-600:780-788.
- Unieke samenwerking tussen vis- en tomatenkwekerij. (n.d.). Retrieved November 2, 2018, from http://www.duurzametoekomst.be/water/een-unieke-samenwerking-tussen-een-vis-en-tomatenkwekerij
- Wilingma, E. & Parree, P. (2016) The Cross Visit Method Deliverable 2.4: An Improved Methodologic Approach Report on the development and final methodology for the AgriSpin Cross Visits. Final version as of 10.11.2016 of deliverable 2.4 of the Horizon 2020 project AgriSpin. EC Grant agreement no: 652642
- **https://www.telegraph.co.uk/business/successful-partnerships/heinz-ford-tomato-fibre-bioplastic/**
- **http://vlaanderen-circulair.be/nl/doeners-in-vlaanderen**

funded by European Commission

funded by European Commission