Curricula on Smart Greenhouses in the Framework of the NEGHTRA Project

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Abstract

Next Generation Training on Intelligent Greenhouses (NEGHTRA) is a specialized training project that addresses knowledge transfer in precision agriculture based on specific needs and challenges. However, competition with new production areas threatens the profitability of farms and forces the rethinking of production strategies. This situation may be aggravated by the growing uncertainty in the markets. In addition, the intensive agriculture sector is considered by society as one of the main causes of, as well as the most affected by, climate change. Specifically, greenhouse growers must rethink their production strategy to promote sustainable production, with special emphasis on the use of new materials and technologies to improve the climate, irrigation, and fertigation, and reduce inputs and waste, the use of renewable energies, and the circular economy. The digitization of agriculture aims to improve and / or simplify all the processes included in the productive activity (data collection, communication and storage of information, analysis and interpretation of data, evaluation or diagnosis of the state of the crop, preparation of recommendations, decision-making and action). Finally, it is necessary to develop capacities that favour innovation and entrepreneurship to strengthen the sector and promote the resilience of this farms.

NEGHTRA has the following target groups a) Higher Education Institutions and Research Institutions, which will update the training *curricula* portfolio, b) agricultural intermediaries that provide counselling and training to the farming communities, and c) the farming community. In this work, we present the *curricula* that can be used to provide the necessary capacities to improve the sustainability of production, promote the resilience of farms, increase the efficiency of crops, and contribute to improving the social recognition of growers.

Keywords: training, knowledge transfer, precision agriculture, sustainability, climate change.

1. Introduction

The European Union considers education, training, and youth, among its key areas for supporting citizens in their personal and professional development. The Erasmus+ program is a key component for achieving the objectives of the European Education Area, the Digital Education Action Plan 2021-2027, and the European Youth Strategy. European citizens must improve their knowledge, skills, and competences to be part of an increasingly changing, multicultural and digital society. The Erasmus+ program supports opportunities for personal, socio-educational, and professional development. To increase the qualitative impact of its actions and guarantee equal opportunities, the Program must more successfully reach people of different ages and of diverse cultural, social, and economic origins. It is therefore essential for the program to reach out to individuals with fewer opportunities, including people with disabilities and immigrants, as well as citizens of the European Union living in remote areas or facing socio-economic difficulties. In doing so, the Program should also encourage its participants, particularly young people, to become involved and learn to participate in civil society, raising awareness about the common values of the European Union. In addition, developing digital skills, and competencies and skills in forward-thinking fields such as combating climate change, clean energy, artificial intelligence, robotics, analysis of large amounts of data, etc., is essential for the sustainable growth and cohesion in Europe in the short and medium term. The program can make a significant contribution by stimulating innovation and reducing Europe's knowledge, skills, and competences gap. Within the Program, Knowledge Alliances are transnational projects between higher education institutions and companies to work on common issues with the general objective of consolidating Europe's innovative capacity and promoting the modernization of European higher education systems. They focus on one or more of the following: developing new, innovative, and

multidisciplinary approaches to teaching and learning; stimulate entrepreneurship and business skills of university teaching staff and company personnel; exchange knowledge and collaborate on finding new solutions (European Commission, 2020).

The proposals of the European Commission on the Common Agricultural Policy during the 2021-2027 interval aim to boost the sustainability and competitiveness of the agricultural sector to significantly contribute to the European Green Deal, especially within the framework of the "Farm to Fork" and the Biodiversity Strategy. In particular, the proposals focus on ensuring fair treatment and economic stability of farmers, setting more ambitious goals for the environment and climate action, and maintaining the primary place of agriculture in European society (European Commission, 2021). To achieve these general goals, the European Commission has established the following specific objectives:

- To guarantee a fair income to farmers. In 2018, farmers earned on average just under half of what could be earned in other jobs, while it was 37% a decade ago in 2008. The agricultural income per worker steadily increased over time to 18,200 EUR in 2019. Direct payments provide a safety net to farmers, which account for about 1/4 of the agricultural income.
- To increase competitiveness. The trade balance in the EU-27 is positive, and followed a positive trend in which both imports and exports increased over time. 2019 was a record year for both imports and exports of EU agrifood products.
- Rebalancing power in the food chain. Agriculture is characterised by a stagnant and low share of value added in the value chain (around 25% of the total value added), due to high input costs, variation in production and incorporation of new services.
- To take action against climate change. Greenhouse gas emissions (GHG) from agriculture have declined substantially between 1990 and 2010. Since then, emission levels appear to be relatively stable. Emissions from agriculture (including croplands and grasslands), accounted for roughly 13% of total EU GHG emissions in 2017.
- To protect the environment. The nitrogen surplus in the EU-27 remained stable in the last decade (2005-2015) at around 50 kg N per hectare per year. The target under the Farm to Fork strategy aims to reduce the nutrient losses on agricultural land by 50% by 2030. An important area of focus in the greenhouse sector is the exploration of optimal energy management.
- To preserve landscapes and biodiversity. Landscape features are providing many benefits to agro-ecosystems and the wider environment. Currently, about 0.5% of the agricultural area is covered by landscape features. In addition, 4% is land lying fallow.
- Support generational renewal. In the EU-27, the share of farmers younger than 35 years of age, in the total number of farm managers, decreased between 2010 and 2016 to 5%.
- Maintain dynamic rural areas. The employment rate in rural areas has increased, and the gap with urban areas almost disappeared in 2018, when 72% of the working-age population (aged 20 to 64) was employed in rural areas. In addition, the rural poverty rate in the EU-27 decreased over time from 30% in 2010 to 24% in 2018. It showed a continuous downward trend between 2010 and 2018. At the end of 2018, 52% of rural households were served by a Next Generation Access network, compared to 81% of total EU rural households. There was a clear improvement on the situation over time in rural areas, but closing the connectivity gap of rural areas with regard to Next Generation Access remains a challenge.
- To protect quality and safety. The overall sales of veterinary antimicrobials across the EU-27 decreased by more than one third between 2010 and 2017, weighted for those MS that provided data each year. The total area under organic farming is increasing in the EU-27, covering almost 13 million hectares in 2018. With 8% of the total utilized agricultural area under organic farming in 2018, the EU-27 area follows a positive trend. Finally, it should be noted that in the EU-27, the share of managers with basic agricultural training equals 23%, whereas 9% attained a full agricultural training in 2016. This share rather slowly increased between 2010 and 2016. Full agricultural training means any training course equivalent to at least two years full time training after the end of compulsory education and completed at an agricultural college, university, or other institute of higher education in agriculture (European Commission, 2021).

The Executive Agency for Small and Medium-sized Enterprises of the European Commission, in its report on the Technological Trends in the Agri-food Industry, sets out key messages to understand the situation and perspectives of the sector (Van de Velde, 2020):

- The agri-food sector is composed of both agriculture & farming and food processing activities. In the face of global change, including demographic change and climate change, the challenge remains to deliver a sustainable food and agricultural production system (FAO, 2017). Advanced technologies are essential for enabling the agri-food industry to increase efficiency in production, while limiting the global impact of food production on the environment. Through developments in precision agriculture and farming, as well as smart food processing, the agri-food industry is responding to these challenges with increased digitalisation and the uptake of advanced

technologies (Van Woensel et al., 2016). Changes in the agri-food industries are also driven by consumer demand for food safety, security, traceability and higher quality, and the value of food products. The EU is an agricultural production leader and exporter of products, creating over 44 million jobs in the EU in the wider agri-food industry (European Commission, 2017).

- Technology shifts in agri-food are occurring in line with the shift to Industry 4.0. As industrial processes are becoming increasingly digital, automated, and connected, an agri-food 4.0 is coming into place. Advanced technologies across the agri-food industry include Internet of Things, Advanced Manufacturing, and Photonics - together with sensors, and include the use of robotics and especially co-bots. Overall, the value chain is becoming increasingly digital, supported by farm management systems and tools to manage and oversee activities at the farm and production levels. Sensors are utilized in farm and animal sensing, as well as in the form of smart sensors for food packaging. Consumers are increasingly interested in high quality food, but also in information flows associated to the origins and impacts of food products and consumer products.
- Transformations and fundamental shifts in agri-food require diverse advanced skills. According to agri-food company websites that reference specific terms associated with advanced technologies, Industrial Biotechnology is the term most associated with the agri-food sector company websites, followed by Robotics and Big Data. Further prominent categories include Advanced Manufacturing and Cloud technologies. It can be observed that France, Spain, and Italy are leading in terms of absolute number of professionals with advanced technology skills employed in the agri-food sector. The results emphasise the growing importance of digital technologies and digital skills in the agri-food industry. The five technological skills with the highest growth within the previous year (from 2018 to 2019) included AI followed by Security, Blockchain, IoT, and Big Data.

Next Generation Training on Intelligent Greenhouses (NEGHTRA) is a specialized Erasmus+ Knowledge Alliances training project, which begun in November 2020, and is expected to last three years. It addresses knowledge transfer in precision agriculture based on specific needs and challenges, identified from a comprehensive need analysis. The project aims at the development of an adaptable and flexible lifelong learning system, for its application in theoretical and practical training on intelligent greenhouses. This will be achieved by:

- Utilizing a training system that will be flexible, responsive, and adaptable enough to accommodate the fast evolution of the economic and environmental sectors, as well as the new technologies.
- Creating national/regional Reference Contact Centers (RCCs) organized by intermediate beneficiaries to remotely assist end-users.
- Including farmers' unions and agricultural associations, which facilitates the acquisition and dissemination of knowledge.

NEGHTRA ensures high quality and efficient teaching: - the teaching material will be available in 7 languages; - the lifelong learning system will incorporate theoretical and practical components, assisted by instructional videos and demonstrations of good practices; - the reference capacity of the national/regional RCC's provision of adequate initial education; and - the continuous improvement of the system by incorporating new teaching material and technologies. This project supports the equal opportunity and accessibility to education and learning, irrespective of any personal, social, or economic background. The training targets the supply of job-specific knowledge, skills, and key competencies to young farmers for the use of new technologies in their profession, and invokes their increased employability and active citizenship. It also provides for a HEI level of knowledge, albeit in laymen's form, to comply with farmers' needs without any formal education, and to effectively provide them with the opportunity to use new technologies. NEGHTRA aspires to deliver young farmers the knowledge of how innovation, entrepreneurship, and technology utilization can benefit their businesses, personal skills, and competence development. The multi-disciplinary scope of this project and conjunctions with various partners maximizes the dissemination of knowledge in all productive aspects of the industry. Throughout the project, emphasis is given to the reinforcement of the quadruple helix concept by infusing its mindset and practices into all related activities, facilitating stakeholder collaborations for economic and societal development, as well as for building the Reference Contact Centres for user support and enhancement of exploitation and sustainability of the project (Figure 1).

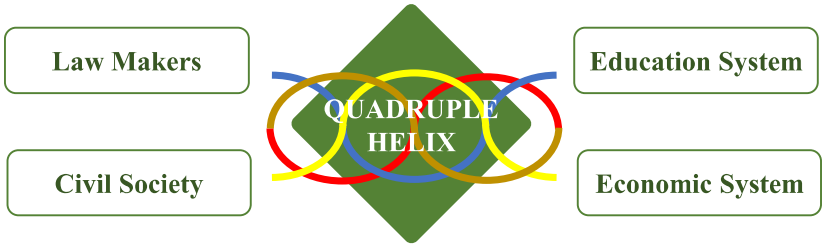

Figure 1. Schematic of the quadruple helix reached by NEGHTRA.

The target groups are: - HEIs and RIs which will update the training *curricula* portfolio; - agricultural intermediaries, which provide counselling and training to the farming communities, and: - the farming community of the participating countries and beyond. The training will be delivered to two distinct groups:

- 1st tier learners including HEIs/RIs staff/researchers, intermediary staff and trainers, local stakeholders, and regional authorities engaged in agricultural development.
- 2nd tier learners including farmers of any size and type of cultivation and students.

All the educational material will be free and available through the e-training platform, where users assess a specific learning process. It will also help in administration, documentation, tracking, and recording of the learning process. The website will facilitate the link between the users and the e-training platform. The educational materials offered therein could be used for distance education and professional training.

The objective of this work is to present a description of the modules included in the NEGHTRA project *curricula* aimed at 1st tier learners. In all cases, the scope, description and learning topics are included. The following sections will briefly present the components of the consortium and the partners associated with the project. In addition, a description of the study on the analysis of training needs will be made. The results of the preliminary training needs analysis and the *curriculum* proposals will also be presented, and finally some conclusions supported by these preliminary results will be described.

2. Materials and Methods

Below is a description of how a previous analysis of training needs was carried out and how the material for the design of *curricula* was prepared.

2.1. Training needs

A needs analysis research was conducted by the partners using an open-ended questionnaire and covering all relevant parameters of training for greenhouse farmers. The partners reached their key stakeholders within their domain including staff, members, trainers, farmers, innovative initiatives, farming schools, VET organizations etc. so that they captured the main issues of training in this sector.

2.2. *Curriculum* Design

The training material will be developed by a consortium made up of 5 Higher Training Centres, 4 specialized SMEs, and 6 groups of intermediaries (1 agro-ICT group, 1 research institute, 1 farmer's federation, 1 farmer's association, 1 specialist in FP, 1 agricultural school), each contributing with their experience and dissemination capacity, in seven languages. The consortium is composed by:

- University of Patras (Greece)
- Geotechnical Chamber of Greece (Greece)
- TTMI Consulting Ltd. (Greece)
- Università degli Studi di Bari Aldo Moro (Italy)
- Confagricoltura Puglia (Italy)
- Istituto Formazione Operatori Aziendali (Italy)
- Leaf Net LTD (Cyprus)
- Cloudpharm Private Company (Greece)
- Institut National de Recherce pour l'Agriculture, l'Alimentat (France)
- GIP Formation et Insertion Professinnelle de l'Academie de Nic (France)
- Universidad Miguel Hernández de Elche (Spain)
- Universidad de Almería (Spain)
- Consejo Superior de Investigaciones Científicas (Spain)
- Grupo HISPATEC Informática Empresarial SA (Spain)
- Universidade de Evora (Portugal)
- ITC Murska Sobota (Slovenia)

The training material will be completed by 5 associated partners with direct access to existing and potential agricultural communities: (i) Formations Vert D'Azur Antibes, Agriculture high school, France; (ii) Surinver El Grupo, Agrarian Producer Cooperative, Spain; (iii) Cooperatives Agro-Alimentaries, Farming and Agrifood Cooperative, Spain; (iv) Coexphal, Association of Fruit and Vegetable Producer's Organizations of Almería, Spain; (v) SLOVCHAGR, Institute for agriculture and forestry Murska Sobota, Slovenia.

3. Results and Discussions

3.1. Training needs

The three top concerns in greenhouse farming were: Knowledge, technology, and crops. Use of energy, fertigation, costs, and selling prices were also common findings. Regarding technological knowledge, it was found that farmers were aware of them, but were limited to fertigation systems, the reason being the lack of their available time and skills to learn, evaluate and use them. Also, there was lack of qualified personnel to assist in implementing these new technologies. The relevant technological parameters in greenhouse cultivations were: - environmental control, fertigation, and smart farming; - market, available resources, and management of production process; and - management of climate control (Table 1). Energy consumption related concerns were found to be: - Irrigation systems & indirect energy use for fertilizers & materials & efficient use of resources, and use of solar energy; - Cooling systems in the summer or heating systems in the winter; and - Climate control.

Table 1. Results of the training needs analysis.

Top concerns in greenhouse farming	Knowledge
	Technology
	Crop
Relevant technological parameters in greenhouse cultivations	Environmental control, Fertigation and Smart farming
	Market, available resources, and management of production process
	Management of climate control
Main issues in innovation uptake	Lack of knowledge, digital/environment management skills and qualified personnel/skills
	Small farm size
	Economic and Financial issues
	Need for Demonstration of Innovation Advantages
	Sensors, wireless connection remote management for climate and fertigation
	Information uncertainty, market information, survival farming
	Useful to integrate consultants and agriculturalists
Training issues in greenhouse farming	Small farms/all day work by owners, thus no free time for training
	Old age farmers with low academic education
	Recent younger farmers open to training
	Short course duration, difficult to understand new technologies
	Few available offers for specific greenhouse training
	Need for specific training on sustainable and precision agriculture
	Various types of training course according to education/skill levels

As for the attitudes regarding smart farming, greenhouse farmers and young farmers were more open to innovation than open field and old farmers. There was more interest in fertigation, and there was a lack of knowledge/interest from small size farmers. The main issue in technological adaptability were: - knowledge or lack of it; - lack of skills and understanding new technologies; - lack of technical training and distrust, and; - lack of qualified personnel.

Most importantly, regarding the training issues in greenhouse farming, the key outputs are: - small farms/all day work by owners, thus no free time for training; - old age farmers with low academic education; - recent younger farmers open to training; - short course duration, difficult to understand new technologies; - few available offers for specific greenhouse training; - need for specific training on sustainable and precision agriculture; and - various types of training course according to education/skill levels.

To summarise the Needs Analysis findings, the greenhouse cultivation lacks updated technological knowledge due to time, skills, and attitude constraints. There is an awareness of available solutions, but not of their relevancy and usefulness in their particular cases. Larger farm units and younger farmers are more prone to uptake innovation, and this process can be accelerated for all farmers using training and consulting services.

3.2. *Curriculum* design

The project *curriculum* for 1st tier learners is comprised of 14 modules, 10 on technologies and crop, and 4 on knowledge and entrepreneurship. Below is an overview of all the included modules.

3.2.1. Coverage & PV

The aim of this module is the acquisition of knowledge for the identification of suitable greenhouse covering materials. These must guarantee a protected environment inside that provides an adequate microclimate for the plants, in relation with the climate of the geographical area, the growing season, and the crop species. The learning topics are: (i) notions on concepts and principles on radiometric properties of greenhouse covering material to define its radiation

behaviour; (ii) notions on concepts on the physical and mechanical properties of the most-utilized covering materials in the Mediterranean area; (iii) notions on concepts and principles applied to Photovoltaic textiles for PV shade screens; (iv) notions on best practices for greenhouse covering material; and (v) skills for choosing greenhouse covering material.

3.2.2.Irrigation & Fertigation

The main objective of this course is to train students on irrigation, fertigation, biostimulants, indigenous arbuscular mycorrhizal fungi (AMFs), and nutrient analysis. All of this is needed for students to achieve their educational goals and to be able to understand the different forms, techniques, use, and application of these elements in agriculture. All this, under the premise that a correct use of these techniques can be very useful. The learning issues are: (i) to know different forms and applications of irrigation, products that can improve the quality of the crops, different forms of cultivation, and diagnostic methods to assess the quality of plants; (ii) show students the evolution of the sector, adapting to new technologies to make students aware of the importance of being up-to-date in the sector, interest in new technologies and method of use, and focus new knowledge to obtain higher quality products in a manner that is more sustainable with the environment; (iii) offer a perspective on the current state of the sector. All of this will allow the application of the techniques learned in a concisely and appropriately manner, depending on the needs.

3.2.3.Climate Technologies / Equipment

The aim of the module is to present, inform, and educate students on climate technologies and greenhouse techniques, and to design and manage the main greenhouse climate control systems to make production economically, socially, and environmentally profitable. The training topics are: (i) notions on concepts and principles applied to greenhouse climate control; (ii) notions on greenhouse climate control techniques; (iii) notions on best practices for greenhouse climate control; and (iv) skills to implement and/or use greenhouse climate control technologies.

3.2.4.Energy management

The aim is to understand the importance of the sustainable use of energy. Identify and analyse measures of energy savings, and energy efficiency improvement towards a sustainable production (reduce environmental impacts and costs). The training issues are: (i) overview of energy use/demand; (ii) energy audits; (iii) energy measurement; (iv) energy saving / energy efficiency; and (v) renewable energies.

3.2.5.Climate management

In this activity, two problems related to the control of greenhouse production processes are presented, specifically the analysis of a computer tool for the control of climatic variables inside greenhouses, and the analysis of a real system for the control. The learning topics are: (i) to explain the advantages and the need for the application of automatic control techniques in the fundamental processes of greenhouse crop production, specifically the control of climatic variables, irrigation and fertilizer injection; (ii) to describe the necessary elements (sensors, controllers and actuators), that compose this particular type of control systems; (iii) to show the necessity of using advanced control techniques such as table set control or parallel feedforward control to improve disturbance rejection, as well as to describe the principles of operation of these techniques; (iv) describe the cascade control technique due to the operation of the actuation systems required for night time control of the greenhouse's indoor air temperature, by using a hot water pipe heating system; and (v) show the need to use a supervisory system for extreme situations that operates with priority over the designed control system.

3.2.6.Automation

This course aims to introduce students to the new technologies related to Automation and Robotics used in the agricultural field, and the specific control techniques that allow the correct performance of the different systems that constitute an automated environment, as they are often not properly implemented in a specific productive environment. The learning issues are: (i) to acquire a solid base of knowledge about automatic control that allows them to analyse low and medium level control systems, recognizing their fundamental modules, and the techniques used for their design and adaptation to the evolution which these types of technologies will undergo, as they have a great future perspective; (ii) to show the student the industrial tasks in which the computer, programmable logic controllers, artificial vision, and robots can be used as basic automation tools. This allows students to become aware of the need for automation in the industrial sector, and focus their basic knowledge of industrial engineering from a process automation point of view; (iii) to offer a view of the systems that can currently be found already automated in the industrial sector. This will allow the application of the concepts and techniques learned in real systems that already exist on the market, the comparison of the different systems to study their advantages and disadvantages, namely, it will be possible to select the appropriate system according to the characteristics of the environment, and to introduce a series of basic engineering tools to perform mathematical calculations, simulation, and programming tools, elementary in process automation.

3.2.7.Greenhouse Digitalization

At present, new technological tools such as IoT, Big Data, Machine Learning and others are available that can help

build more efficient, sustainable, and competitive systems. Digitization allows the processing of large volumes of data from different sources, providing knowledge to tools which advise the farmer on making decisions in real time about the crop. This module will describe digital and information technologies, a broad term that includes all aspects of the uses of information technology, not including only hardware and software, but also communication technology, software engineering, and administration of the infrastructure for managing and delivering information. The training objective are: (i) to teach students the need to understand the importance of digitization in agriculture and help them acquire the necessary knowledge for the digitization process of the sector; (ii) to show the different systems and communication protocols available on the market, providing improved knowledge for the interconnection of devices through the different communication networks (Sigfox, Lora, GPRS,…); (iii) to know the main concepts of the Internet of Things (IoT) ecosystem; (iv) to know the importance of the data, and the correct manner to analyse data; (v) to introduce tools in charge of acquiring added value to data such as DSS, Big Data and Machine Learning, and Deep Learning; (vi) to acquire basic knowledge on the different cloud systems available on the market: Infrastructure as a Service (IaaS), Software as a Service (SaaS), Platform as a Service (PaaS), Model as a Service (MaaS); and to meet different IoT applications and current commercial solutions applied to agriculture.

3.2.8. Best farming practices in greenhouse cultivation

This present module focuses on introducing the students to the concepts of integrated management in agricultural production with best farming practices in greenhouse cultivation. Emphasis is given to the specifications for the integrated management of horticultural crops. The training issues are: (i) Standards, and requirements of Integrated Management in Agricultural Production; (ii) International, European, and national standards for Agricultural greenhouse Products; (iii) Integrated Management System Certification; (iv) harvesting and post-harvesting of greenhouse vegetables; (v) pollution management, environment, biodiversity; and (vi) best management practices for sustainable cultivation of greenhouse vegetables (FAO, 2013).

3.2.9. Circular economy

The aim of this module is the acquisition of knowledge on the circular economy with the objective of 'closing the loop' by greater re-use and recycling of materials used for protected cultivation. The learning topics are: (i) principles of circular economy; (ii) notions on the use of plastic materials in protected cultivation; (iii) notions of management of agricultural plastic waste; (iv) notions on practices to reduce and recycle agricultural plastic waste; (v) sustainable use of water and energy; and (vi) water & energy management.

3.2.10. High added value greenhouse cultivations

The present module focuses on how intelligent greenhouses can assist with producing consistent and high-quality raw materials for industrial high added value products (functional foods, dietary supplements, and cosmetics). Emphasis is given to peculiar species (i.e., aromatic plants and herbs). The learning issues are: (i) Aromatic and medicinal plants. Applications in Food, Drug and Cosmetic Industries. General introduction to Aromatic and Medicinal Plants and their applications to Health. Provide information regarding herbal raw materials in Food, Drug and Cosmetic Industries. Current status and future trends. Brief market description for these sectors; and (ii) Technical processes, skills, and know how. Describe the current technologies available to cultivate aromatic and medicinal plants in a greenhouse environment. Explain the advantages, their limitations, and the required technical skillset.

3.2.11. Business basics

The aim of this module is to understand the various requirements and dimensions of business, particularly in terms of responsiveness to problems and decision-making, as well as the tools and management techniques. The training topics are: (i) Strategic Management (creating a business and strategic plan for business); (ii) Marketing (to know how to market business through different channels (traditional, web, and social media); (iii) Accounting and Finance (which records to keep, how to keep them and how to file them, and where to find financing and how to manage it); (iv) Operations Management (choosing and managing suppliers, logistics, and supply chain management); and (v) People Management (hiring employees and how to manage them).

3.2.12. Owning / Managing a fresh produce business

This module analyses the basic economic concepts used for the theoretical and empirical economic analysis of how farms choose to use the available production parameters and study price setting through the interaction of supply and demand in the agricultural product markets. The training issues are: (i) Production theory: function of production, relations of production inputs, the optimal combination of production inputs and products, the productivity of production inputs; (ii) Cost theory: the concept of production costs, the distinction of cost forms; (iii) Greenhouse operation, production costs, revenues, and incomes; (iv) Theory of agricultural products demand, demand elasticities; and (v) Theory of supply of agricultural products, supply elasticity.

3.2.13. Quality & Safety

This module aims to help personnel to plan and prepare for food safety and quality audits, and to effectively engage

with auditors. The learning topics are: (i) requirements of food safety and quality audits; (ii) expectations of the external food safety auditor; (iii) audit preparation and priorities in the months before the audit; (iv) critical food safety documentation; (v) critical food safety practices; (vi) internal audits and system reviews; (vii) what to do in the weeks leading up to the audit; (viii) what to do on the day of the audit; and (ix) how to follow up on the audit and manage the outcome.

3.2.14. Entrepreneurship in agro-food sector and new agri-business models

The present module introduces the basics. The learning issues are: (i) innovation and entrepreneurship in the agricultural businesses. Introductory notes; (ii) bringing an idea into the market. Initial steps and decisions; (iii) building networks with Universities, SMEs, Investor schemes. Access to research infrastructures; (iv) technology transfer applications to provide Ad hoc solutions in cultivation/production; (v) intellectual property protection and management. Building assets from the farm; (vi) new business models. The case of regional innovation structures in the agri-food sector (innovation valleys, incubator & accelerators for supporting start-ups, spinoffs, and existing enterprises.

3.3. Training characteristics

The training material includes innovative solutions that strengthen green and efficient agricultural production. In addition, the *curriculum* will present guidelines on how to use innovation and technology for agribusiness development. This also enhances creativity and entrepreneurship at all levels of education and training. The project specifically targets young farmers and provides them with the knowledge, skills, and competencies to adopt new technologies for existing crops or to develop new crops with the use of new technologies. An electronic training platform (system) will be used to communicate the training material in 7 different languages, allowing interactive education and training between students and teachers. An e-learning platform will also facilitate learning using virtual technology with embedded information from 3 pilot greenhouses. E-learning techniques not only promote adult learning, but also make learning more engaging and increase the quality of guidance systems, as well as their potential to reach broader farmer populations across Europe. NEGHTRA aims to develop a quality assurance system, which will not only ensure the effective use of resources to provide the highest quality teaching, but will also contribute to the improvement of the governance and leadership of higher education institutions.

The methodologies and approaches that will be adopted and applied to learning and training systems, clearly showcase its innovative character. NEGHTRA will develop and deliver customized training material accompanied by an innovative e-training platform with embedded features from pilot intelligent greenhouses, which will enable interactive education and training, and mobile access. This platform will also represent the means for providing the beneficiaries with intense conventional training, including workshops, seminars and virtual classroom meetings.

The implemented training modules will remove the barriers which impede the fluent diffusion and application of knowledge and available technologies and know-how in the field. Researchers and experts will be able to exploit their already-conducted studies, achieving their spatial dissemination while assisting decision makers. This will contribute to spread the knowledge, techniques, and models, and plan their future strategies towards the sustainable management of agricultural air and water quality of the different growing systems.

Finally, within the content of the quadruple helix, the project empowers the collaboration and strengthens the relationships between agro-related industry, intermediate organizations/regional authorities, academia, and civil society. Accordingly, the project seeks the involvement of the agro-related industry in teaching practical entrepreneurial experience and research, for example.

4. Conclusions

Next Generation Training on Intelligent Greenhouses began in November 2020, and is expected to last three years. Its aim is to design, develop, and deliver training on sustainable and profitable smart greenhouses, suitable for individual farmers / agricultural schools and especially useful for remote and vulnerable communities. The present work presents an overview of its main characteristics, and describes the learning objectives and competencies of the modules that comprise its *curriculum*, both its technical nature and the business and entrepreneurship model. The project is expected to help advance the achievement of the sustainable development goals by developing innovative approaches to improve the quality of teaching and learning, stimulating entrepreneurial skills, and co-creating knowledge between the university and the company.

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