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NEW CURRICULA AND TEACHING PROGRAMMES ON SUSTAINABLE AGRICULTURE: THE "SAGRI" PROJECT

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SUMMARY

In the European Union almost 50% of the territory is covered by farmland, which means that agriculture plays a key role in land management, having also a huge responsibility in the preservation of natural resources. In order to practice a sustainable agriculture, farmers and other agricultural operators must adopt correct and environmentally-friendly practices, using appropriate technology and complying with relevant regulations. Recent developments in science and technology are however still unfortunately unutilized in many situations even since - as a recent survey conducted for the European Commission revealed - only 17% of farmers has finished a basic or full training specifically focused on agriculture-related disciplines. In the present paper, the main results achieved so far by the European Project: "*Skills Alliance for Sustainable Agriculture* - SAGRI" are presented. SAGRI is a project financed by the Erasmus+ Programme of the European Commission aimed to give a decisive answer to the request of better trained farmers, agricultural workers and extension staff, thanks to structuring specific courses aimed to increase their knowledge, competence and skills in the field of agro-environmental technology for sustainable agriculture. Through the institution of suitable concerted and standardized study curricula and relevant teaching programmes, the SAGRI Project is aimed to increase the technological level for agricultural operators, then promoting their employment as well.

Keywords: sustainable agriculture; new technologies; farmer skills; study curricula

INTRODUCTION

In the European Union almost 50% of the territory is covered by farmland (both arable and permanent grassland), which means that agriculture plays a key role in land management, having a huge responsibility in the preservation of natural resources as well. In order to practice a sustainable agriculture, farmers responsible for the management of farmland and other agricultural operators must adopt correct and environmental-friendly practices, using appropriate technology and complying with relevant EU regulations. Recent developments in science and technology, that could be an added value for farmers' crop and land management, are still unutilized in many situations, since farmers have not been introduced to them or have not been trained to use them. "Sustainable agriculture" means an integrated system of plant and animal production practices aimed to:

– Satisfy human food and fiber needs;
– Enhance environmental quality and the natural resource base for agricultural activities;
– Make an efficient use of non-renewable and on-farm resources;
– Sustain the economic viability of farm operations;
– Enhance the quality of life for farmers and society as a whole.

Recent developments in science and technology - that could be an added value for farmers' crop and land management - are however still unfortunately unutilized in many situations, since farmers have not been introduced to them or have not been trained to use them. A critical issue in the 21st century for increasing the sustainability of agricultural production is therefore constituted by the changes and adaptations required in agricultural education aimed to more effectively contribute to improve sustainable agricultural production and rural development. Poor training of agricultural extension staff has been identified as a crucial part of the problem of the relative ineffectiveness of much of extension in the field. This applies not only to extension staff, but to agricultural operators in general. Nevertheless, training of human resources in agriculture is often not a priority in the EU countries' development plans. A recent survey conducted for the European Commission revealed indeed that the majority of the farmers in Europe have received only secondary education (57%) while 15% had only primary education, 16% post-secondary (non-tertiary) education and 12% had tertiary education. Only 17% of farmers finished a basic or full training focused on agriculture-related disciplines.

In the present paper, the main results achieved so far by the European Project: "*Skills Alliance for Sustainable Agriculture* - SAGRI" (Sagri, 2016) are presented. SAGRI is a project financed by the Erasmus+ - *Sector Skills Alliances* - Programme of the European Commission aimed to give, through a trans-national multi-actors approach, a decisive answer to the request of better trained farmers, agricultural workers and extension staff, thanks to structuring specific courses aimed to increase their knowledge, competence and skills in the field of agro-environmental technology for sustainable agriculture. Through the institution of suitable concerted and standardized study curricula and relevant teaching programmes specialized into the most recent developments of science and technology, the SAGRI Project is aimed to increase the technological level for agricultural operators. The official certification of the SAGRI courses will make agricultural operators even more employable, thanks to an enhanced mobility across EU countries, since their own competences will be recognized under the framework of the SAGRI system.

MATERIALS AND METHODS

The contents and relevant Learning Outcomes of the SAGRI courses result from a cross-linking approach connecting the expectations coming from the primary sector – through the farmers associations which are participating into this Project – on the basis of the awareness of farmers, agricultural workers and extension staff in terms of green and digital/technological skills, once they are intersected with the most recent developments in science and technology - detected and focused by the Universities belonging to the SAGRI Partnership Consortium. They concern:

– Green skills. Skilled agricultural workers increasingly need to have a holistic awareness of sustainability, *i.e.*: understanding climate changing, the need for carbon emission reduction, renewable energy, biomass valorisation and biofuels, water resources and ecosystems management, integrated pest management, to be updated with new regulations and legislation.
– Digital or technological skills. Skilled agricultural workers will need to be able to understand and apply new technologies related to: primary production for both food and non-food uses, soil science, crop and livestock genetics, agri-chemicals, precision technology and general purpose technologies such as remote sensors, satellites and robotics.

Framework conditions under which the SAGRI courses are conceived consider that:

– Technology itself is not sufficient and a well-trained team is also required. Investing solely in technology will not ensure successful implementation of ICT applications; it is necessary to invest in a team that can effectively perform tasks, investing in capacity development of end users who can ensure the sustainability of the project.
– Complex ICT or complex platforms are not necessarily essential: technologies already being used by farmers are anyway taken into consideration.
– Contextual factors: local factors such as the lack of adequate resources must be taken into account beforehand (*e.g.* electricity, gender issues, limited network coverage and low bandwidth, local languages, *etc.*). Implementation approaches need to identify the specific needs of the intended users by working in collaboration with them. There is not one single solution that fits all projects: context, policies, marketing efforts and incentives are all essential factors to ensure participation from community members.
– Data integrity and security must be ensured throughout the project and when using ICT applications. Experts agreed that leveraging location data and other metadata with individual records helps maintain integrity.
– Agricultural worker or farmer would have a minimum education level of high school and a basic knowledge and experience in agriculture at a practical level.

Of course, not all agricultural workers or farmers have sufficient knowledge to understand all the new developments in agriculture applied research, since some of them require a minimum education level. Therefore, prior to identifying the skills, the agricultural worker profile to whom they are destined was defined.

Seven major areas were therefore identified in significant technological developments that can help farmers for a more sustainable agriculture:

1. Precision technology.
2. Remote sensing to assess land capability.
3. Integrated pest management in plant protection.
4. Agricultural reuse of organic residuals.
5. Drip irrigation and water-conserving technologies.
6. Renewable energy and its application as green agricultural energy source.
7. Bioenergy and energy crops.

These skills are the basis for the developing of new innovative curricula integrating the latest advancements of the "agri-tech" sector, and training courses for agricultural workers according to the EQF/ECVET framework.

RESULTS AND DISCUSSION

Transversal skills

Although the analysis was mainly focused about the job-specific skills for agricultural workers, there are some generic and transversal skills that agricultural workers need to have in order to adapt to changing production processes, and to other sector-specific changes and challenges (Cedefop, 2016). Agricultural workers are the women and men who labour in the crop fields, orchards, glasshouses, livestock units, and primary processing facilities to produce the world's food and fibres. They are employed on small- and medium-sized farms, as well as large industrialized farms and plantations. In an integrated farming approach, a correct management and a balanced approach of every farm decision is needed and some specific points cover essential elements of a whole farm management approach:

- Organisation & planning: Planning and evaluation of practices is essential to ensure environmentally responsible production and continuous improvement.
- Human & Social Capital: Standards of employment practice, health and safety at work, and occupational training need to embrace EU standards of employment practice as minimum standard. Using local markets will help to maintain both local business and livelihoods and can also improve efficiency. Besides, open and active involvement of the farmer in local community's life can help generate transparency and trust. This can also include hosting farm visits or holding open days for the public.
- Energy Efficiency: Awareness of sustainable development and the responsible management of natural resources are central. More careful and selective use of inputs, conservation tillage practices, reducing fossil fuel needs where possible and striving for optimum instead of maximum yields are just some strategies to increase the input-output-ratio and hence energy efficiency.
- Water Use & Protection: Use of water resources should be balanced and programmes which determine crop needs should be used. Protecting natural ground and surface water bodies is a key for maintaining and enhancing the environment, wildlife and biodiversity.
- Climate Change & Air Quality: By working in the open, using fossil fuels, keeping livestock, storing and spreading manure and by other agricultural practices, the emission of greenhouse gases and other air pollutants is unavoidable. Farmers' decisions may help to keep carbon stocks in soils by allocating land to annual or perennial crops, to grassland, woods or buffer zones (such as hedges, grass strips, *etc.*). Some practices on reduced tillage or cover crops or incorporation of crop residues to soil may even increase the carbon sequestration to a certain extent and also help to improve air quality.
- Soil Management: Soil is fundamental to agricultural systems and a rich soil ecosystem contributes to crop and livestock performance: "The quality of life below ground determines productivity above". Good soil husbandry ensures the long-term fertility of soil aids yield and profitability and reduces the risk of soil damage such as erosion, compaction and associated environmental concerns.
- Crop Nutrition: Knowledge of the soil nutrient status is a decisive tool for ensuring that only the necessary and recommended amount is applied. The decision making process

involves crop demands, the supply that is in the soil and available nutrients from farm manure and crop residues. A balanced approach to fertilisation should be adopted, practices should be adapted to local situations, thereby reducing risks of environmental pollution by fertilisation.

- Animal Husbandry, Health & Welfare: Health and welfare of farm animals are linked with performance. Farmers employ and demonstrate techniques directed towards meeting the needs of the livestock and maintaining the animals in good health, comfort and low stress, allowing for natural behaviour to the greatest possible extent.
- Landscape & Nature Conservation: Protecting and enhancing wildlife and biodiversity of the landscape is of great importance within the concept of Integrated Farming. Management practices should consider biodiversity effects such as the thread to larches during mechanical weeding. The structural diversity of land and landscape features will create floral and faunal abundance and diversity.
- Waste Management & Pollution control: Wastes, including farm manure, must be seen as a valuable resource in terms of saving money and reducing pollution. Farming effluents should be managed to optimise recycling and re-use, thereby minimising effects on the environment. Recycling of external materials such as sewage sludge should only be considered if there will be no hazard to soil and environment due to critical ingredients such as heavy metals *etc.*

Specific skills

Precision agriculture

Precision Agriculture (PA) may improve agricultural yield and reduce potential environmental risks. The main benefits are (Iris, 2014):

- Monitor the soil and plant physicochemical parameters: by placing sensors (electrical conductivity, nitrates, temperature, evapotranspiration, radiation, leaf and soil moisture, *etc.*) the optimal conditions for plant growth can be achieved.
- Obtain data in real time: the application of sensing devices in the fields will allow a continuous monitoring of the chosen parameters and will offer real time data ensuring an updated status of the field and plant parameters at all time.
- Automate field management: by incorporating a Decision Support System (DSS) in Precision Agriculture environment, the best conditions for the specific soil and plant species will be automatically optimised based on the data obtained by the sensors. The DSS will suggest the best moment for watering (or whether there is need or not), the need to irrigate to wash the salt content due to an excess in the radicular area, the need to fertilise, *etc.*
- Save time and costs: by introducing a PA system in the daily operation of an agricultural exploitation, time is saved due to the on-line measurement methods. Data from the sensors are automatically transmitted to a central server and this can be consulted using a Smartphone or Laptop. Or even, e-mail or SMS alerts can be programmed to notify the field owner when there is a need to irrigate, fertilise or address any issue in their properties. Moreover, costs in terms of water, pesticides and others could be optimised and easily reduced.
- Improve the farmers' image: by using PA technology, not only the yield and profits will be increased but also the perception of the general public and Public Administration

(through Smart Agriculture and environmental care) towards agricultural activity will be enhanced.

In this way, Precision Agriculture seems to bring many benefits to farmers and land owners who decide to use technology to manage their fields.

Applications of remote sensing to assess land capability

The applications of remote sensing to assess land capability in agriculture are designed to provide the farmer with timely information about crop progress. Here follow just some of the benefits that can be gained from the use of remote sensing:

- Early identification of crop health and stress.
- Ability to use this information to do remediation work on the problem.
- Improve crop yield.
- Crop yield predictions.
- Reduce costs.
- Reduce environmental impact.
- Crop management to maximise returns through the season.
- Crop management to maximise returns during harvest time.

Remote sensing data, used appropriately and at the right times of the season, has the ability to provide benefits to crop health and hence improve production (Regional Institute Online Publishing, 2016).

Integrated Pest Management in plant protection

Integrated Pest Management (IPM) in plant protection focuses on the long term application of ecologically-friendly biological methods such as natural predators, resistant plant strains, sterile male technique, *etc.* IPM aims to slowly reduce the use of pesticides via biological control methods. The main benefits of IPM are (Greentumble, 2016):

- Slower development of resistance to pesticides: pests can develop a resistance to pesticides over time. When the applications of the chemicals are used repeatedly, the pests can develop a resistance to the pesticides via natural selection, where the pests that survive the application of the chemicals will pass on their genes to their offspring.
- Maintaining a balanced ecosystem: the use of pesticides may eradicate the pest population. However, there is a risk that non-target organisms are also affected, which can result in species loss. IPM can eradicate pests while maintaining the balance of the ecosystem.
- Better cost *vs.* value margin: The reduced usage of pesticides is more cost effective in the long term, as IPM controls pests when there are surges, as opposed to the regularly timed application of pesticides.

Agricultural reuse of organic residuals

The agricultural reuse of organic residuals may provide agronomic and environmental benefits that were either not previously well understood and/or that are critical to addressing emerging environmental issues associated with climate change. Environmental benefits are possible from manure application if suitable manure management strategies are applied, as well as timing and placement follow best management practices. When compared to more conventional fertilizer, manure properly applied to land has the potential to provide environmental benefits including:

- Increased soil carbon and reduced atmospheric carbon levels.
- Reduced soil erosion and runoff.

- Reduced nitrate leaching.
- Reduced energy demands for natural gas-intensive nitrogen (N) fertilizers.

Several long-term manure application studies have illustrated its ability to slow or reverse declining soil organic levels of cropland. The ability of manure to maintain or build soil organic matter levels has a direct impact on enhancing the amount of carbon sequestration in cropped soils. Manure organic matter contributes to improved soil structure, resulting in improved water infiltration and greater water-holding capacity leading to decreased crop water stress, soil erosion, and increased nutrient retention (Extension, 2016).

In the recent years the attention has been focused also on the energy from biomass, while the exploitation of agro-industrial residues, although being materials with a limited energy potential, will fit into the goals of the general energy efficient conservation and sustainable protection of the natural resources, as well as within the implementation of the concept of bio-economy (Statuto et al., 2013). Agricultural co-products, by-products and waste (Statuto & Picuno, 2017), other than being considered as an important energy source, are indeed important factors for restoring the level of organic matter in the soil (fig. 1).

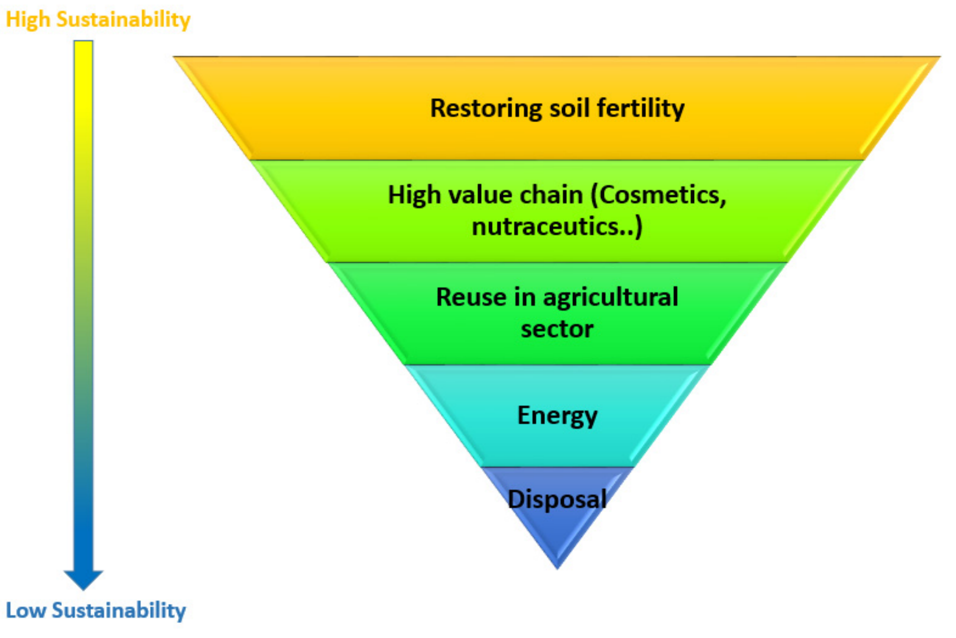

Figure 1. Agricultural by-product, co-product and waste management hierarchy.

Drip irrigation and water-conserving technologies

Drip irrigation is a type of micro-irrigation that has the potential to save water and nutrients by allowing water to drip slowly to the roots of plants, either from above the soil surface or buried below the surface. The goal is to place water directly into the root zone and minimize evaporation.

The advantages of drip irrigation and water-conserving technologies are (Agriinfo, 2015):

- Maximum use of available water.

– No water being available to weeds.
– Maximum crop yield.
– High efficiency in the use of fertilizers.
– Less weed growth and restricts population of potential hosts.
– Low labour and relatively low operation cost.
– No soil erosion.
– Improved infiltration in soil of low intake.
– Ready adjustment to sophisticated automatic control.
– No runoff of fertilizers into ground water.
– Less evaporation losses of water as compared to surface irrigation.
– Improvement of seed germination.
– Decrease of tillage operations.

Renewable energy and its application as green agricultural energy source

Renewable Energy of all sizes has become a familiar sight around the world for a wide variety of reasons, including economic, environmental, and social benefits. Main advantages coming from renewable energy and its application as green agricultural energy source are (Harvest Energy Solutions, 2016):

– Clean water: Turbines and solar panels produce no particulate emissions that contribute to mercury contamination in lakes and streams. Renewable energy also conserves water resources. For example, producing the same amount of electricity can take about 600 times more water with nuclear power, and about 500 times more water with coal.
– Clean air: Other sources of electricity produce harmful emissions, which contribute to global climate change and acid rain. Wind and solar energy is pollution free.
– Mining & transportation: Harvesting the wind and sun preserves resources since there is no need for destructive mining or fuel transportation to a processing facility.
– Land preservation: Wind farms are spaced over a large geographic area, but their actual "footprint" covers only a small portion of the land resulting in a minimum impact on crop production or livestock grazing. Large buildings cannot be built near the turbine, thus wind farms preserve open space.

The diffusion in the use of biomass as a new energy source may determine changes in its characteristics of naturalness, biodiversity and visual quality of the rural landscape (Statuto et al., 2017). The modern concept of landscape may be not indeed only limited to the visual perception that humans receive from the land, since this effect is the results of the interaction among several different ecosystems, that means living natural chains connected to the morphological, geo-pedological, hydrological, meteorological, *etc.* characteristics of a certain area. As well as the word "landscape" itself expresses the role of shaping the lands by natural forces, an "*Energyscape*" may be considered as the effect derived from the role played by energy sources as a force shaping the visible features of the Earth's surface in delimited areas (Statuto & Picuno, 2016). Therefore, similarly as for cultural landscapes, an energyscape is fashioned from a natural landscape by an energy exploitation (Statuto et al., 2016). Energy is the agent, natural area is the medium, the energyscape is the result (fig. 2).

Figure 2. The "Energyscapes"

Bioenergy and energy crops

Energy crops are unique because they don't just produce renewable energy – they also provide other environmental and economic benefits (Clean Energy Council, 2016), since they may lead to both new feed and energy from harvesting, in the framework of a circular economy. Other than creating renewable energy, bioenergy and energy crops also provide:

– Rural & regional benefits.
– Distributed baseload power.
– Competitive cost proven renewable energy generation.

Energy crops provide therefore great economic and social opportunities for rural and regional communities. Farmers, truck drivers, contractors, suppliers, as well as local restaurants and shops are all provided with an economic boost. This provides a source of permanent fulltime employment unique from the seasonal workforce in many rural and regional areas. Energy crops also encourage the development of new and innovative farming techniques and can provide economic returns on land and crop residue with no other identifiable market or environmental value. As these communities deal with the impacts of climate change, energy crops provide rural and regional areas with a more self-reliant labour force less vulnerable to the impacts of drought and flood.

CONCLUSIONS

Traditionally, pen and paper have been used to collect data in the field and for monitoring and evaluation of projects in rural areas. However, this approach is time consuming and susceptible to human error that may affect productivity and accuracy. Information and communication technologies are now being used widely with remarkable positive results to perform these tasks in agricultural development projects. In a recent global discussion organised by the World Bank to point out the benefits of the new tools and methods with respect to the traditional ones, experts from various fields and organisations around the world shared their experiences and discussed the ways in which they were using ICT – mobile phones, tablets, applications, software, *etc.* – to collect data in the field, and to perform Monitoring and Evaluation (M&E) in development projects, while also working closely with rural communities and taking their feedback. The discussion has been summarised in a policy brief and outlines the benefits of using ICT for data collection.

The advancements in the agricultural technologies sector, and in particular new technologies for the above mentioned skills, is going to be transferred to agricultural workers in the frame of the SAGRI Project. Particular focus will be put on environmental technologies that are of direct interest for the participant end-users, but also for European farmers in general. The SAGRI Project is focused on novel practices and methods for applying advancements in environmental technologies to an agricultural and environmentally challenged society and to facilitate the farmers everyday activities. The information will be applied in order to facilitate the transfer of the most critical points of it to the agricultural workers. The acquisition of these skills is an important step to achieve a more technologically advanced and social, economic and environmentally sustainable agriculture. At the present, it is evident the role of the farmer, who knows not only the traditional cultivation to produce different crops, but that has to take into account the new techniques and technologies able to contribute to a sustainable agriculture.

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