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REGIONE AUTÒNOMA DE SARDIGNA
REGIONE AUTONOMA DELLA SARDEGNA

LIVINGAGRO

B2B EVENT
Multifunctional Olive Systems

# CATALOGUE OF INNOVATIONS

## A COLLECTION OF INNOVATIONS FOR MULTIFUNCTIONAL OLIVE SYSTEMS

## LEBANON - JULY 2022

**WP 2 OUTPUT 2.8 - ACTIVITY 2.8.1**

## LIVINGAGRO | Cross Border Living Laboratories for Agroforestry

**ENI CBC Med Programme 2014 – 2020, first call for standard projects**
**Grant Contract Number: 38/1315 OP of the 29/08/2019**
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# Project Summary

"LIVINGAGRO – Cross Border Living Laboratories for Agroforestry" is a project funded under the ENI CBC Med Programme 2014–2020, first call for standard projects, and refers to thematic objective A.2 "Support to education, research, technological development and innovation," priority A.2.1 "Technological transfer and commercialization of research results."

With a total budget of 3.3 million euros and a 2.9 million EU contribution through the ENI CBC Med Programme, the LIVINGAGRO project involves 6 organizations from 4 different countries (Italy, Greece, Lebanon and Jordan) and addresses the challenge of knowledge and technological transfer in Mediterranean agriculture and forestry systems for achieving and sharing good practices aimed at sustainable production, protecting biodiversity, enhancing transfer of innovation and increasing profitability for territories and main actors as well as stakeholders involved. Using an open innovation-oriented approach for co-creating economic and social values and interactions between supply and demand, eliminating geographical and cultural barriers, two Living Laboratories are being established focusing on multifunctional olive systems (LL 1) and grazed woodlands (LL 2).

**Expected results**

- ✓ Creation of two Laboratories (Living Labs) on the themes of multifunctional olive systems and grazed woodlands whose activation phases include the localization and identification of relevant stakeholders;
- ✓ Establishment of "Living Labs" through specific agreements between public and private entities;
- ✓ Development of the dedicated ICT platform;
- ✓ Creation of a public-private community which shall launch pilot actions aimed at experimentation;
- ✓ Signing of at least 4 research agreements between universities and research centers in collaboration with the economic operators of the project's partner countries;
- ✓ Organization of 20 field visits by research institutions to assess and identify companies' innovation needs;
- ✓ Cooperation between at least 8 companies and research organizations for the development of innovative activities and services;
- ✓ Activation of 6 courses related to the creation of innovative companies / startups;
- ✓ Creation of 10 corporate-scientific brokerage events in Jordan (4 B2B events), Lebanon (4 B2B events) and Crete (2 B2B events);
- ✓ Analysis and development of 10 new products / services for the agroforestry sector;
- ✓ Activation of 20 technology transfer and intellectual property brokerage services for companies, universities, research institutes and the general public.

**Partnership**

Beneficiary (LP):

Regional Forest Agency for Land and Environment of Sardinia (Fo.Re.S.T.A.S.), Italy

Partners (PPs):

PP 1: Italian National Research Council, Department of Biology, Agriculture and Food Science (CNR), Italy

PP 2: National Agricultural Research Center (NARC), Jordan

PP 3: Lebanese Agricultural Research Institute (LARI), Lebanon

PP 4: Mediterranean Agronomic Institute of Chania (MAICH), Greece

PP 5: ATM Consulting S.a.s. (ATM), Italy

Associated Partners (APs):

AP1: Autonomous Region of Sardinia, Dept. of Environment Defense

AP2: Autonomous Region of Sardinia, Dept. of Agriculture and Agro-pastoral Reform

AP3: Coldiretti Sardinia

AP4: Regional Association of Sardinian Breeders

AP5: The Lebanese University (Faculty of Agronomy, Beirut)

**Project Duration**

September 2019 – August 2023 (48 months)

# INTRODUCTION

**USING THE CATALOGUE**

We want both senior and less experienced readers to be able to engage with the innovations featured here in order to assess whether these innovations are relevant to the local or global challenges facing them. The catalogue therefore assumes a certain level of understanding of olive growing, olive oil production, and livestock farming, but includes highly technical and scientific terms and notions only where this is essential for a basic understanding of the innovation. This is not a technical manual, but a catalogue intended to provide an overview of some of the innovations that may be useful to those involved with multifunctional olive systems in order to help bring together stakeholders and innovators who may be able to collaborate to solve common problems. Contact information is provided in order to facilitate networking.

**ABOUT INNOVATIONS**

The European Commission (EC) defines innovation in agriculture and forestry as "'a new idea that proves successful in practice.' In other words, the introduction of something new (or renewed, a novel change) which turns into an economic, social or environmental benefit for rural practice." It may be "technological, non-technological, organisational or social, and based on new or traditional practices. A new idea can be a new product, practice, service, production process or a new way of organising things, etc. Such a new idea turns into an innovation only if it is widely adopted and proves its usefulness in practice." LIVINGAGRO has gathered a wide range of innovations in this catalogue which project members believe will prove useful for those who work with multifunctional olive systems.

In 2015, European Commissioner Carlos Moedas established three central policy goals for EU research and innovation: open innovation, open science and open to the world. Open innovation, according to the European Commission, means "opening up the innovation process to people with experience in fields other than academia and science. By including more people in the innovation process, knowledge will circulate more freely." The LIVINGAGRO team invited numerous stakeholders to share their concerns about needs for innovation related to multifunctional olive systems then attempted to identify innovations related to those concerns, including innovations coming from nonscientists outside academia.

Open science, according to the EC, "focuses on spreading knowledge as soon as it is available using digital and collaborative technology." Along with LIVINGAGRO's website, Facebook page, B2B meetings, and other outreach efforts, this catalogue represents an effort to spread knowledge about innovations to the people who need them as soon as possible after project members identify the innovations. Open to the world "means promoting international cooperation in the research community," and LIVINGAGRO involves direct collaboration among four countries in the Mediterranean region, both in and beyond the European Union: Italy, Greece, Jordan, and Lebanon.

**HOW WE CREATED THE CATALOGUE**

Having identified potentially useful innovations, the partners of LIVINGAGRO suggested a template for innovators to complete. This included assessing the stage of readiness of a potential innovation, as well as which type of challenges it addresses. Taking into consideration the needs expressed by stakeholders, LARI's research team and technical team reviewed the information provided. Following this review, we went back to the innovators to address questions and fill in gaps, then incorporated the responses into the innovation descriptions.

**SECTION 1: Intercropping and Preparing for Climate Change in Olive Groves**

Traditionally, olive groves in Greece have included plants such as legumes, cereals, herbs, vegetables, walnuts, grapevines, and truffles. Such a combination of two crops grown at once on a plot of land is known as intercropping. When it includes trees and an annual crop, it is also a type of agroforestry. The traditional agroforestry practice of intercropping offers many benefits over a monoculture--benefits for the soil, the farm, the broader environment, and (as a result) the farmer. Recommending that olive farmers consider innovating by adapting new, improved versions of traditional agroforestry practices, numerous scientists now provide specific advice to help farmers achieve the greatest possible benefits.

Intercropping increases olive groves' sustainability by adding to their biodiversity and stabilizing the soil, thus reducing trees' vulnerability to pests, diseases, and climatic stresses. The greater diversity in plant life enables a larger variety of organisms in the soil, as well as more beneficial insects, pollinators, and birds. With intercropping, the soil benefits from increased porosity, improved drainage, less erosion, and decreased nitrogen and phosphorus leaching, which means fewer valuable minerals lost and less pollution of groundwater and surface water. Fewer pesticides and nitrogen fertilizers are required, and olive trees tend to be healthier, which benefits the planet and the farmer. In addition to saving money on pesticides and fertilizer, farmers may also benefit financially both by producing higher quality olives and by harvesting a second crop. They can either sell this product (as in the case of the recently popular avocados) or use it as a natural soil enricher or an animal feed (as with legumes).

One of the most important crops for the Mediterranean region, the olive tree will be subject to increasingly harsh abiotic stresses due to climate change in the coming years. Abiotic stress comes from environmental conditions that can harm plants and reduce their growth and yield, such as extreme temperatures, soil salinity, and drought. (Biotic stress, on the other hand, is caused by living things such as insects, weeds, bacteria, viruses, or fungi.) Shifting cultivation zones, depletion of organic matter, desertification, degradation of water resources, and other challenges make it imperative to prepare for the future, for example by intercropping and by using trees that can resist the effects of climate change.

**Innovation 1: Chickpea intercropping in olive groves**

- **Background**
  In the regional unit of Fthiotis in Central Greece, agroforestry is a traditional land use system in which farmers used to combine olive production with grazing and arable crops in the same plot. In this way they ensured a steady economic return every year, irrespective of weather conditions or other types of hazards. In recent years, interest in that traditional combination of olive orchards with arable crops revived, so it was tested in a three-year field experiment in Central Greece. Agricultural systems in that area mainly involve field crop production (58%), vegetables (3%), vines (1%), and tree plantations (27%). Typically, farms are small (average size < 3 ha) and managed as private enterprises. Land is usually owned or rented by the farmers. It is estimated that there are almost 7,000,000 trees in the prefecture, which plays a leading role in Greece's edible olive production.

- **Keywords**
  olive, silvoarable system, agroforestry system, annual crops, cereal, chickpeas, olive growing, olive groves, olive production

- **Methodology**
  Sow seeds of an annual crop such as chickpeas between tree rows in olive orchards with widely spaced trees (100 trees/ha). 80 kg of seeds are required for each hectare.

- **Specifications**

  A local variety of chickpeas that is resistant to fungal infections is preferred (such as Amorgos chickpeas with olives in Fthiotis). A wide variety of species can be used as intercrops between the trees, depending on the region and the compatibility of species to be intercropped. Local experts should be consulted to determine the best species for a given area.

- **Impact**

  Chickpeas' low water demand renders them ideal for intercropping with trees of similar water requirements in the Mediterranean and other dry ecosystems. Additionally, they provide nitrogen to the soil, thanks to the symbiotic relationship of their roots with nitrogen-fixing bacteria. This results in a reduced need for nitrogen fertilizers, lower expenditure on such fertilizers, and a reduced risk of nitrogen leaching and subsequent soil and water contamination. The annual crop (chickpeas on this occasion) can be sold on the market as a high quality product with significant nutritional value, increasing the farmer's income.

- **Filled gaps**

  This traditional approach, which was used in the past in silvoarable systems with a variety of species (including nitrogen fixing plants), encourages the preservation of agroforestry systems by their final users, the farmers, by providing financial incentives for their preservation. This is important since these valuable agroforestry ecosystems are closely linked to Greece's natural and cultural heritage. They also provide numerous high-quality, mostly organic products, such as olives, olive oil, and annual crops, thus contributing a great deal to the rural economy. Additionally, intercropping requires that the land be cleared of understory vegetation, and such clearing reduces the risk of forest fires.

- **Limitation**

  The intercropping species must be chosen carefully by experts to ensure compatibility with local conditions and lower light availability, as well as eliminating the possibility of pathogen transfer between the plant components.

- **Next steps/potential extension**

  To evaluate the possibility that silvoarable systems can provide multiple products while supporting local stakeholders, an experiment was established under the framework of the AGFORWARD project. This practice has also been tested in other countries. The results have been encouraging in all cases. Different seed mixtures could also be tried in different areas to determine which ones work best in each location.

- **Find out more**

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**Innovation 2 : Effect of soil management and different cover crops on soil characteristics, olive production and olive oil characteristics**

- **Background**

  The majority of Lebanese olive orchards are considered traditional rain fed and are planted mainly with the local Baladi variety, which is a highly alternate bearing variety. This has a strong negative impact on the ability to reach new olive oil markets, since consistent amounts of high-quality olive oil would need to be provided each year. In Lebanon, many studies have focused on the effect of cultivar, irrigation, harvesting, and processing systems on the quality of olive oil. However, no studies have been conducted on the effect of fertilization, and especially the effect of green fertilization, on soil fertility, tree productivity, olive oil quality, and alternate bearing of the olive tree. Since soil fertility and nutrient requirements may vary among different olive orchards according to the tree age and olive production system, it is necessary to determine how to provide the best fertilization system at the minimum cost. The objective of this experiment is to assess how combining minimum tillage, an overwinter cover crop, and rational fertilization effects the performance of the olive trees—mainly their alternate bearing behaviour--as well as increasing farmers' income through multiple cropping.

- **Keywords**
  Olive orchards, olive oil, local olive variety, soil fertility, fertilization, alternate bearing, cover crop

- **Methodology**
  The 2960 $m^2$ field originally contained 70 trees from the Baladi variety which had been planted in 1996 in 7 columns and 10 rows, with a spacing of 6.5m between rows and columns. Thirty trees chosen for being homogenous were included in our studies. To avoid waterlogging during the season of heavy rains, it was necessary to drill a water collector canal at the end of the field just before the start of the experiment in November 2020. Trees were also pruned and sprayed with copper, and the soil was plowed and prepared for the establishment of the five following treatments using a completely randomized design with six replicates (6 trees) per treatment:
    - Faba beans (*Vicia faba*)
    - Broccoli (*Brassica oleracea var. italica*)
    - Barley (*Hordeum vulgare)* with common vetch (*Vicia sativa*)
    - Spontaneous vegetation as a negative control
    - Fertilizers + herbicides as a positive control

  In December, leaf samples were taken (120 leaves/tree) and laboratory analysis was carried out to determine the level of N/P/K/B/Fe/Zn in the leaves. In addition, soil samples from two depths (0-20 cm and 20-40 cm) were taken to measure the pH, texture, calcium carbonate and organic matter, in addition to the ammonium, nitrate, phosphorus and potassium levels. Analyses of leaves and soil samples were repeated at the end of the experiment.

  Plant height and yield were measured for the faba plants. For the broccoli, the fresh and dry weight of the biomass were taken. Samples from the vetch and barley treatment as well as the spontaneous vegetation were taken, and weeds were separated and dry weight was measured. Biomass production was taken at the termination of the trial in April.

- **Specifications**
  The implementation of this experiment is simple and low-cost. Soil nutrient recycling and moisture and soil temperature were assessed. Fruit samples were collected for olive oil yield and some other chemical, physical and sensory analyses.

- **Impact**
  Reduce alternate bearing behavior in olive trees
  Improve productivity and oil yield and quality
  Increase farmers' income by introducing secondary crops (green faba bean) in the olive orchards

- **Filled gaps**
  Farmers can save money on inorganic fertilizers.
  The use of forage legume (vetch) provided more soil nitrogen through atmospheric fixation as compared to the vetch/barley, barley alone, or the spontaneous weeds.

- **Limitation**
  Low or high rainfall in some regions may reduce the germination rate and biomass production.

- **Next steps / potential extension**
  Other benefits from the cover crops (forage crop, better water infiltration, protection from soil erosion), better productivity and olive oil quality.

- **Find out more / contact information**
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## SECTION 2: Olive Tree and Olive Oil Authentication

Whether determined through visually observable characteristics (phenotype), genes (genotype), or chemical analysis, olive variety and olive oil grade identification can be useful to nearly everyone who works with olives or olive oil, from producers and millers to researchers and consumers. Consumers and those who serve them, for example, are increasingly interested in learning about the exact type and origin of products, including the types of trees their olive products come from. Seeking high quality and anxious to avoid fraud, many prefer authentic, certified products. Researchers, growers, breeders, and conservationists want to know which olive cultivars are growing in which areas and conditions in order to assess biodiversity, consider how to prepare for climate change, and prepare to preserve genetic resources. Cultivar identification is also fundamental to overcoming confusion concerning varietal names, a common obstacle in current olive research. Innovative ways of identifying olive cultivars are especially useful for all of these reasons, and more.

### Innovation 3: Discriminating among EVOOs and table olives obtained from clonal variants of olive cultivars with high territorial value

- **Background**
  There is currently a problem with the marketing of certain traditional olive products: there is confusion about some widely diffused cultivars that are known by different names but appear identical when analysed by standard molecular markers. Some extra virgin olive oil (EVOO) and table olives, in fact, come from olive cultivars that have grown in a particular area since ancient times, giving them what could be called a high territorial value as typical local varieties. Some of these products are being confused with olive oil and olives from the same genotype (variety) that are grown in distant areas, sometimes under different names (known as variety synonyms); these can be called clonal variants.
  The typical local varieties are generally ancient, yielding very high quality products, having been vegetatively propagated from a single common ancestor and grown in the same area for centuries. In many cases, they are protected by different commercial brands or by European Protected Designations of Origin (PDOs) or Protected Geographical Indications (PGIs). However, these valuable, protected local varieties may

run into problems with fraudulent practices, as EVOOs and table olives deriving from the same cultivar (genotype), but coming from different locations—the clonal variants—are sometimes mixed with the protected local varieties, or products from other areas may be incorrectly identified as coming from the protected local varieties. This type of fraud is unfair to both producers and consumers.

DNA analysis is the only way to detect the varietal composition of extra virgin olive oils and table olives with high territorial value. When analyzed with standard DNA markers, products deriving from these cultivars show the same profile and are indistinguishable from each other. But somatic (genetic) mutations may have occurred and fixed in the varietal population thanks to their clonal origin (clonal variants), as recently identified in other fruit crops, such as grape and orange. Genome re-sequencing represents the most powerful way to detect these somatic mutations, allowing scientists to scan all single DNA bases, identify effective polymorphisms, and develop markers useful to distinguish within-cultivar variants. In other words, this is a new way scientists can distinguish between ancient cultivars with a particular local origin, and clonal variants of the same variety that are grown in a different area.

- **Keywords**

  EVOO, table olives, olive oil, extra virgin olive oil, traceability, intra-cultivar variability, clonal variant, somatic mutation, genome re-sequencing, SNP markers, DNA authentication, genotyping, territorial food product, PDO, PGI

- **Methodology**

  This innovation refers to the development of new markers able to distinguish among clonal variants of cultivars with different names in different territories.

  In order to develop clonal-specific SNP markers to distinguish between products of the same cultivar from different locations, it is necessary

  - to collect plant material from trees of the same olive genotype from different olive growing territories under different local names;
  - extract high molecular weight genomic DNA;
  - sequence all DNA samples through WGS technique in order to obtain at least 30X coverage, in order to keep only real somatic mutations and avoid sequencing errors;
  - do a bioinformatic analysis of all data to detect all intra-varietal differences;
  - convert most robust polymorphisms into effective markers to distinguish among olive clonal variants;
  - apply these SNP markers to EVOOs and table olives.

  The methodology developed through these tasks can be applied by producers and traders of EVOO and table olives in order to authenticate the products they market, while the control authorities will be able to use an additional analytic tool to prosecute frauds and discriminate between real and fake products.

- **Specifications**

  Currently, re-sequencing of different clones of the Sardinian olive cultivars Bosana and Corsicana da Olio is being undertaken in order to identify SNP markers able to distinguish different clones within the populations of these cultivars in comparison to the same varieties grown in other regions under other names.

- **Impact**

  The availability of new SNP markers able to distinguish among clonal variants of the same cultivar will make it possible to unmask the fraudulent use of unexpected clones for high-valued territories, enabling an overall improvement of quality standards and promoting varietal excellence at the regional level. Producers, oil millers, retailers, importers, authorities, consumers and others involved in the olive oil supply chain will benefit from the application of the analytical method based on clone-specific markers.

- **Filled gaps**
  The lack of analytical methods able to distinguish among different clones of the same variety makes it more likely that oils and table olives derived from clones grown in low-value territories or with a compromised commercial image will be passed off as more desirable products and sold at higher prices to unsuspecting consumers, with control agencies unable to uncover the fraud. This new method will enable the detection of such fraud, thus discouraging these fraudulent practices.

- **Limitation**
  This innovation is currently being developed for just two olive varieties. There is a vast bibliography that claims to demonstrate the presence of different clones in many varieties of olive trees, from morphological, agronomic and molecular points of view. However, these differences have never been confirmed in the light of more detailed analyses. Only data from the cultivar genome sequencing can allow the detection of real variants.

- **Next steps/potential extension**
  Work is being done on local cultivars in Sardinia and other regions, collecting, propagating and evaluating different minor and unknown cultivars to define their agronomical behavior and select those that could be used in olive oil and/or table olive production. Additional technologies could be made available in the near future. This work could be expanded to cover more varieties in different areas.

- **Find out more**

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**Innovation 4: OliveID, an image-based tool to identify olive cultivars based on a numeric analysis of size, shape, and structure**

- **Background**
  The morphological analysis of olive leaves, fruits and pits—the analysis of their size, shape, and structure--can be an efficient tool to help characterize and discriminate between cultivars, as well as establishing relationships among them. The olive cultivar identification tool described below is based on a simplified scheme that has been adopted by the International Union for the Protection of New Varieties of Plants (UPOV).

- **Keywords**
  olive cultivar identification, morphological analysis, olive fruit, olive leaf, olive endocarp, types of olives

- **Methodology**
  To get started with this new automated methodology, the user takes a picture of an olive fruit, leaf or endocarp (pit). The raw image is transformed into a black and white picture. Our new tool uses that picture to quantify many shape related features of the fruit, leaf and endocarp based on strictly defined mathematical specifications, then provides accurate, objective numerical measurements corresponding to the leaf, fruit, or pit's form and structure. Finally, contemporary computer programming techniques and innovative automated algorithms classify the numerical measurements according to the database with the morphological characteristics of each olive cultivar that it is available at the Mediterranean Agronomic Institute of Chania, Greece.

- **Specifications**
  For best results, the fruit, leaves, and pits should be collected from a specific part of the tree at a particular stage of maturity. The pits should be separated from the pulp with a coarse fabric, then soaked in 10% bleach for 5 minutes. For the photos, samples should be placed on top of glass, with the camera fixed on a solid arm above it; a light-blue paperboard makes the best background. Adjustments must be made to transform the image into a black and white photo.

- **Impact**
  Feasible modern image-based methodologies to identify olive cultivars fast and accurately will be highly valuable for farmers, millers, buyers, authorities, and researchers, among others. In the food industry, for example, this new tool could facilitate the sorting of olive batches to obtain monovarietal olive oil at the mill and improve the accuracy of postharvest classification of olives according to such features as fruit surface size and condition for table olives or olive oil.

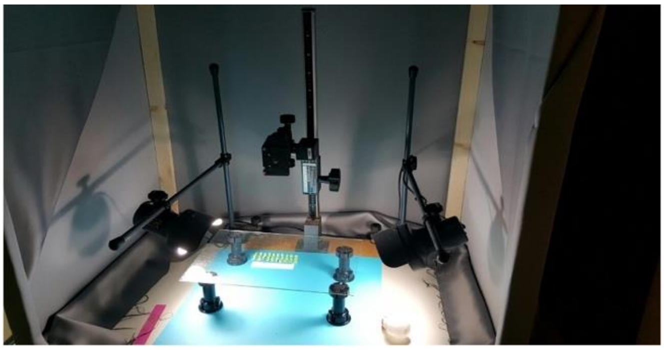

Image 2: Olives prepared for photography (by Konstantinos Blazakis)

- **Filled gaps**
  People commonly identify olive cultivars based on the appearance of fruit, leaves, pits, and other parts of

the plant. However, visual observations require experience and can be subjective, inconsistent, and inaccurate. This integrated automated tool will characterize and identify a large set of olive cultivars more accurately.

- **Limitations**

  The decisions the user must make about which fruit, leaves, or pits to use and how to make adjustments to the image can introduce a subjective element into the process. Care in selection, photography, and adjustments may be challenging for some. Programming currently uses the MATLAB environment; more work will be required for the method to use open programming libraries as well.

- **Next steps/potential extension**

  The next step is the implementation of this innovation in a smartphone application that can be used by anyone anywhere, even in the olive grove. The plan is to drastically simplify both the process and the type of photography required.

- **Find out more**

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**SECTION 3: Harvest and post-harvest management**

**Innovation 5: FT-NIR Analyzer, using Fourier transform (FT) near infrared spectroscopy (NIR) to determine olive oil quality**

- **Background**

  Olive oil quality is a major national policy priority in producing countries, as well as a significant concern for consumers. While measurements of the oxidation level (via the peroxide value and the K232 and K270 values) and the olive oil's purity (delta-k) are important, the quality factor that has the greatest effect on prices is the oil's level of free acidity. The fatty acid composition of olive oil is also a crucial parameter for considering the quality and health benefits of this natural product. With the increasing production and export of olive oil in Lebanon over the years, the demand for high quality olive oil has also been increasing. This has made a fast, cheap, reliable technique for monitoring olive oil quality essential.

- **Keywords**

  Olive, *Olea europaea* L., olive oil production, geographical origin, olive oil quality, fatty acid composition, FT-NIR, near infrared spectroscopy, Fourier transform

Images 3: The Antaris FT-NIR Analyzer (left) and the sample bag inserted in the machine (right) (by Wadih Skaff)

- **Methodology**

  A small sample of olive oil (around 1g) is put in a plastic bag for infrared spectrum acquisition (Right Image). This will provide a great deal of information about olive oil characteristics and quality. The mathematical treatment of the collected IR data (spectra) using chemometrics tools enables a qualitative and quantitative analysis of the olive oil samples. This method is considered fast, inexpensive, and eco-friendly.

- **Specifications**
  - Able to provide quantitative and qualitative analyses of olive oil
  - Reliable determination of olive oil quality
  - Bench-top system, easy to set up and use
  - Inexpensive in terms of time and money
  - Non-destructive analysis in seconds
  - No sample preparation
  - No chemicals
  - Easy to fill plastic sample bags
  - Multilingual software

- **Impact**

  The instrument helps olive oil producers, exporters, and importers determine the quality of their olive oil quickly and inexpensively. For olive oil, the instrument is able to predict the free acidity and the fatty acid profile (oleic, linoleic, and palmitic fatty acids) and to classify olive oils according to their geographical origin in order to detect possible adulteration with oil from other origins. In addition, with just one analyzer, NIR offers a valuable tool for the analysis of the composition of olive leaves (assessment of nutritional status), olives (to guarantee a fair payment scheme), and pomace (to control and optimize the extraction process).

- **Filled gaps**

  While other accurate methods exist, FT-NIR is faster and cheaper than most other methods for determining olive oil quality, the fatty acid profile, and the geographical origin of the oil.

- **Limitation**

  While it is inexpensive to operate, the instrument is expensive to purchase, making it unavailable to many. In addition, before a qualitative analysis by FT-NIR can be completed, a set of chemical measurements (chromatographic, spectrophotometric, titrations, etc.) must be performed on a large number of samples to create the prediction model needed to determine the pre-cited parameters.

- **Next steps / potential extension**

  Future research will focus on preparing the machine to detect the adulteration of olive oil with other vegetable oils.

- **Find out more / contact information**

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**Innovation 6: Using Sumac for Olive Curing**

- **Background**

  Olive treatment using brine or lye causes the depletion of many important chemical compounds that are important to human health. Moreover, traditional curing methods use a concentrated brine solution, resulting in olives with a significant amount of salt. Syrian sumac (*Rhus coriaria*), a commonly used natural spice, has a growing importance due to its increasing usage in the food, cosmetic and pharmaceutical industries. Its rich concentration of tannins and other phenolic compounds makes it a very promising "natural" food preservative with potentially healthier attributes compared to many synthetic preservatives.

- **Keywords**

  Olives, Syrian sumac, preservatives, sodium, shelf-life, sensory changes, curing olives

- **Methodology**

  This innovation aimed at using Syrian sumac to gradually replace the salt brine in traditional olive curing. The experimental design is based on treating the olives with an increasing concentration of ground sumac leaves while decreasing the salt concentration in the presence of lemon slices (added as a flavoring agent).

- **Specifications**

  Olives are soaked in water containing ground Syrian sumac fruits with decreasing salt concentration. The lye is replaced on a weekly basis. This process is followed for three consecutive weeks. The use of sumac as a natural preservative helped cure the olives while enriching them with antibacterial, antifungal and antioxidant agents that are released in the medium.

- **Impact**

  Using sumac in the preservation of olives would result in:

- Olives that are healthier, due to the reduced use of salt in their preservation
- Olives with a relatively good shelf life, as fungi development would be delayed
- Olives with a higher nutritional value thanks to the health benefits of sumac

- The replacement of synthetic preservatives with natural preservatives

- **Filled gaps**
  This innovation could help solve several problems:
  - The depletion of significant health promoters originally found in olives, which occurs during traditional brine-based treatment and preservation
  - The unimpressive nutritional value of table olives prepared in certain traditional ways
  - The high sodium content in olives preserved with brine (a commonly used method in Lebanon)

- **Limitation**
  Fresh olives (rather than previously treated or preserved olives) should be used. It is best to avoid the use of plastic cups and synthetic covers.

- **Next steps/potential extension**
  The use of lye affects the nutritional profile of olives and also plays a role in changing the permeability of the olive skin, which causes both hydrophilic and hydrophobic compounds found in olives to leach out. Ongoing research proves that creating an acidic medium during the debittering process will lead to a more efficient oleuropein removal from olives. This deserves additional exploration.

- **Find out more**
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**SECTION 4: Precision Agriculture**

As the need to feed a growing world population using sustainable, environmentally friendly methods becomes increasingly apparent, more and more farmers are acknowledging the potential usefulness of precision agriculture, which is also known as smart farming and intelligent agriculture. These phrases are sometimes used interchangeably to refer to the utilization of information and communication technologies to minimize farmers' input while maximizing their output. For example, data gathered remotely using sensors on farms can be used to help farmers determine what a farm needs, thereby avoiding excessive application of fertilizers, water, or pesticides, while producing a greater quantity and better quality crops at a lower cost. Proponents argue that the environment, farmers, and consumers all benefit from the increased efficiency and decreased waste.

**Innovation 7: Zen Irriware precision irrigation system**

- **Background**
  In a dry climate such as the Mediterranean region, irrigation is necessary in olive groves with an average annual rainfall of less than 400 mm, in intensive olive groves, and in poor soils. Agriculture is by far the largest consumer of fresh water, accounting for at least 70% of fresh water withdrawals from rivers, lakes and aquifers – more than 90% in some developing countries. It is extremely helpful to conserve as much water as possible in irrigation, since that will result in significant water savings overall.

- **Keywords**

Precision irrigation, precision agriculture, irrigation software, intelligent agriculture, intelligent agriculture databases, saving water, water conservation, irrigation

- **Methodology**

Zen Irriware uses the following information, which is entered into a database:
1. An area's meteorological data (from a private or local source, or free data from a cloud computing service such as Weather Underground)
2. Soil characteristics (from a geo-informatics system or soil analysis)
3. Crop data (planting distances, age, etc.)
4. Quality and availability of water in the area (for full or deficit irrigation)
5. Irrigation method
6. Soil cover
7. Weather forecast and extreme weather events

Taking into account the information mentioned above, Zen Irriware calculates the frequency and quantity of irrigation that each grove actually needs, sending the result to the farmer's smart phone by SMS or email. Farmers can interact with the software by recording irrigation applications, or they can choose complete automation of irrigation, with commands going directly to the solenoid electro-valve and no farmer intervention required.

- **Specifications**

The farmer needs a mobile phone to receive the messages about irrigation of the grove. No special skill is required, and even farmers unfamiliar with new technologies can use the innovation. It is a simple, user-friendly innovation designed for the average producer.

- **Impact**

1. Optimizes use of irrigation water, thus conserving water
2. Minimizes environmental risks (e.g. nitrate pollution)
3. Reduces the cost of production (by reducing inputs)
4. Minimizes soil leaching
5. Reduces root system suffocation conditions
6. Reduces the likelihood of damage from impending extreme weather (heatwave, frost)

- **Filled gaps**

The irrigation of olive groves is generally done without scientific guidance or full consideration of the grove's actual needs, resulting in water waste. Because oversupply does not have a direct impact on trees, farmers feel safer if they provide more water than necessary, especially when its price is low. According to recent surveys, up to 35% of the applied water is lost, since only 65% is used by the trees. In drought years and in dry areas, this water loss can have serious consequences for agricultural production. Zen Irriware can help avoid this.

- **Limitations**

Soil analysis is required. So far used only in Greece.

- **Next steps/potential extension**

Expansion to other countries in the Mediterranean basin.

- **Find out more**
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**SECTION 5: Re-Using Traditional Practices in Agroforestry**

In agroforestry, trees or shrubs are grown in or around pastureland and/or agricultural crops. Silvopastoralism, a type of agroforestry that combines livestock grazing and trees, was and still is a traditional land use system in many areas. For example, in Xeromero, Aetoloakarnania in western Greece, livestock breeders have used the valonia oak forest for grazing as well as collecting acorn cups from the oaks for use in the tanning industry. Agrosilvopastoralism is another kind of agroforestry where livestock is introduced in the field after the completion of the annual crop. On the island of Kea in the Aegean Sea, farmers used to grow cereals and legumes between trees for both human consumption and as feed for the animals. Greek olive farmers have also traditionally grown annual crops for the market or for grazing animals among their trees—or simply allowed livestock to graze on wild plants in the groves. Lately, there has been a gradual abandonment of this kind of combined land use, with a preference for monoculture, such as olive trees grown alone.

However, using forests and olive groves for multiple purposes has many benefits. For example, it ensures a steady and enhanced economic return every year, with a reduced risk of losses due to weather conditions or other types of hazards. Agroforestry can also increase biodiversity, reduce the impact of pests, enrich soil nutrient content, reduce erosion, improve carbon sequestration, and help reduce the risk and severity of forest fires. For these reasons, a return to productive old ways can become a useful innovation that allows farmers and livestock breeders to both increase their incomes from the production of high quality products, and help preserve valuable forest lands and olive groves using sustainable practices.

**Innovation 8: Clearing shrubs and sowing a mixture of grass and legumes in agrosilvopastoral systems**

- **Background**
Farmers on the Aegean island of Kea used to sow a variety of intercrops between oak trees for many uses, including cereals and legumes for human consumption and as animal feed. During a stakeholders' meeting on the island, farmers expressed their willingness to investigate alternative ways of using valonia oak agrosilvopastoral systems to enhance their income. One possibility that was discussed was the promising cultivation of grasses under valonia oak trees. To investigate the effect of oak trees' shade on the intercropping species' development, a controlled experiment was established in an agrosilvopastoral system with valonia oak trees in the southern part of the island. In this system, the valonia oak forest is used for both grazing and acorn cup collection.

- **Keywords**
oak, agrosilvopastoral system, agroforestry system, grazing, feed, financial support, agroforestry, forest fire prevention

- **Methodology**
Clear the shrubs in a traditional oak agrosilvopastoral system, then sow a mixture of legumes and cereals. It can be harvested or used for grazing at the end of the growing season.

- **Specifications**

  A variety of species can be used as intercrops between the trees, depending on the region.

- **Impact**

  Even if the shade cast by the trees limits the production beneath them, the overall production of forage is likely to increase, making this a money-saving plan, according to experiments in Greece and other countries. Another important positive effect of this procedure is that farmers remove flammable biomass when they clear the shrubs, thus reducing the risk of fire and helping to preserve the forest.

- **Filled gaps**

  This traditional approach, which was used in the past in all agrosilvopastoral systems, encourages the preservation of agrosilvopastoral systems by their final users, the farmers, by providing financial incentives for their preservation. This is important since these valuable agroforestry ecosystems are closely linked to Greece’s natural and cultural heritage. They also provide numerous high-quality, mostly organic products, such as dairy, meat, honey, and herbs, thus contributing a great deal to the rural economy.

- **Limitation**

  The intercropping species must be chosen carefully by experts to ensure compatibility with local conditions and probably lower light availability.

- **Next steps/potential extension**

  To evaluate the possibility that agrosilvopastoral systems can provide multiple products while supporting local stakeholders, an experiment was established under the framework of the AGFORWARD project. This practice has also been tested in other countries. The results have been encouraging in all cases. Different seed mixtures could also be tried in different areas.

- **Find out more**

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