Application of 3D LiDAR and satellite detection technologies for developing a comprehensive model for monitoring and improving the productive and economic performance of super-intensive almond orchards

Summary

The traditional rain-fed almond tree training system is based on the classic vase, which normally involves severe pruning and wide plant spacing, due to the limited availability of water. Today, the incorporation of irrigation, new and improved planting materials, technology and the use of more fertile, better quality soils enables new production models, with different systems for managing almond orchards and harvesting.

These new production models included high-density orchards, which are possible thanks to the use of moderate or low vigour rootstocks, which, combined with new varieties, can provide high and early production. Unfortunately, there is still a considerable lack of knowledge on how to manage these new farming systems properly.

For this reason, this project will use image processing technologies to develop new predictive models to identify improvements in the harvest, which will be correlated with different crop shaping and sizing techniques (shaping pruning and green pruning), agronomic management (effective application of irrigation, fertilisers and phytosanitary products, and the use of plant cover) and resource requirements (labour and materials). This will help establish the best working models for super-intensive almond orchards (with varieties such as Avijor and Marinada with INRA rootstock GF-677), in order to achieve high-density orchards (up to 3,000 plants/ha).

Super-intensive almond cultivation has a high technological risk due to the lack of detailed knowledge on the effect of crop intensification; among other modifications, this can impact on plant physiology and its response in terms of early harvests and yield, and indirectly on crop sustainability. This is already being studied and applied to other crops, such as vineyards, stone and seed fruit trees and olive trees, where traditional vase systems have evolved towards systems with higher planting densities and more effective use of resources.

Of particular note in this context is the importance of developing a comprehensive model for monitoring and improving super-intensive almond cultivation that can integrate local, high-resolution measurements from LiDAR (light detection and ranging or laser imaging detection and ranging) 3D scanning systems with lower-resolution but larger-scale satellite imagery. This comprehensive image analysis system will allow high-resolution monitoring of the crop canopy. Crop vegetation development can be continuously correlated with agricultural operations and production, allowing more precise and efficient agronomic management.

Objectives

The aim of this project is to establish a new integrated model for monitoring the new super-intensive almond tree cultivation, based on new technologies (LiDAR and satellite image analysis) which, by measuring the leaf canopy and other phenological parameters, will help establish the best management models for initial crop formation and other maintenance strategies during the season (winter pruning, green pruning, fertilisation, phytosanitary treatments, irrigation needs and use of plant cover) and their sizing towards larger productive areas.

The following specific objectives were established in order to achieve this overall objective:

- Determine the optimum size of the leaf canopy in super-intensive almond orchards (height, width and density) in relation to early production and yield.
- Optimise crop shaping management (winter pruning and green pruning) and other agricultural modifications to obtain optimal canopy size parameters in super-intensive almond orchards.
- Assess the effect of different experimental pruning systems on the development of the leaf canopy of new super-intensive almond tree orchards and determine resource requirements (for labour, fertiliser and phytosanitary treatments, plant cover, water requirements, etc.) associated with each pilot test.
- Reduce the use of resources, mainly phytosanitary products, by means of new models for developing the leaf canopy for new super-intensive almond crops.
- Validate monitoring parameters: leaf canopy (size and density), number of flowers, and the percentage of fruit set, fruit and productive yield as significant parameters in the new models, arising from the correlation between two

image processing technologies (satellite images and 3D LiDAR sensors).
- Define a comprehensive model for continuous crop monitoring based on the relationship established between 3D measurements from a mobile terrestrial scanner and satellite imagery.
- Establish a system of decision-making priorities to be implemented within the integrated model of continuous monitoring of super-intensive almond growing.
- Transfer the comprehensive almond tree cultivation monitoring model for super-intensive farming for validation (continuous improvement of the model) and improve its robustness, with data based on the heterogeneity of different production plots.

Description of the actions carried out in the project

The measures planned in this project are as follows:

I. Parameterising different experimental trials by determining the effect of super-intensive crop variables such as: almond tree variety, crop height, width and density, and modifications to management (pruning and thinning), among others.
II. Implementing image processing, starting with developing monitoring methodologies (remote sensing and 3D LIDAR scanning) and continuing with scans and image and data acquisition and processing.
III. In addition, crops will be monitored (pre- and post-harvest) for correlation with the image processing information and to develop a new management model.
IV. Developing and validating a continuous crop monitoring model, using information generated from previous actions

Final results and practical recommendations

The results of the project are expected to generate analysis of remote sensing technology used as a tool for crop analysis, once corrected and correlated with LiDAR technology. Both technologies now provide valuable information from analysing and processing the images they generate, but a number of drawbacks are associated with their use. On the one hand, satellite image analysis is a very cheap, but not very accurate, tool. This is quite the opposite of LiDAR technology, which generates highly precise and valuable information, yet is expensive to apply, with costs farmers struggle to pay. Thus, cross-referencing information generated by these tools will facilitate the development of new models to optimise remote sensing, making it more precise and applicable in farmers' day-to-day work for decision-making in almond tree cultivation management in new super-intensive models (or any other crop in which the technology is developed). All this will lead to new, more technology-based and precise processes, consisting of applying remote sensing (guaranteed by LiDAR) to different phenological phases of the crop so that farmers can access the information needed to make the best decisions for both optimising crop production and influencing other important aspects of the crop (to speed up the start of production, minimise materials and labour costs, manage the main crop and other secondary crops more sustainably, e.g. using plant cover, and improve productive and economic yields), develop more precise, efficient, sustainable, professional and technology-based agriculture.

Leader of the Operational Group

ORGANISATION: ALMOND FOODS, SL

Coordinator of the Operational Group

ORGANISATION: ALMOND FOODS, SL

Other members of the Operational Group (not recipients of the grant)

ORGANISATION: UNIVERSITY OF LLEIDA CCT
ORGANISATION: GRUP COOPERATIU FRUITS DE PONENT, SCCL
ORGANISATION: NATIONAL ASSOCIATION OF ALMOND HULLING COMPANIES
ORGANISATION: FRUPINSA
ORGANISATION: AGROMILLORA

Subject area(s) of application

☒	Agricultural production system
☒	Agricultural practice
☐	Agricultural equipment and machinery
☐	Livestock farming and animal welfare
☒	Vegetable production and horticulture
☒	Landscape / Territorial management
☐	Pest and disease control
☐	Fertilisation and nutrient management
☐	Soil management
☐	Genetic resources
☐	Forestry
☐	Water management
☐	Climate and Climate Change
☐	Energy management
☐	Waste and by-product management
☐	Biodiversity and environmental management
☐	Food quality/processing and nutrition
☐	Supply chain, marketing and consumption
☒	Competitiveness and agricultural and forestry diversification
☐	General

Geographical area(s) of application

PROVINCE(S)	REGION(S)
LLEIDA	SEGRIÀ

Dissemination of the project (publications, conferences, multimedia, etc.)

All members of this operational group will carry out communication and dissemination tasks, such as:
Participating in sector dissemination conferences.
Drawing up fact sheets.
Publishing project progress on the social media.
Publishing scientific and technical articles by the GRAP.

Project website

More information on the project

PROJECT DATES	TOTAL BUDGET	
Starting date: July 2021	**Total budget:**	€249,928.80
	DACC funding:	€113,967.53
Current status: Under way	**EU funding:**	€85,975.51
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