VALorization of MEDiterranean ALMond orchards: first economic results of the use of intercrops and cover crops

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Context description and conceptual framework

Mediterranean agriculture is increasingly challenged by "*a series of environmental challenges such as water and soil pollution, erosion or biodiversity loss, especially in monoculture systems*" (Alcon et al., 2020). In response, cropping system diversification, through practices such as crop rotation, cover crops, and intercropping, has been promoted as a key strategy to improve resource-use efficiency, enhance agroecosystem resilience, and stabilise farm income (Rodriguez et al., 2021; Viguier et al., 2021).
Within the Mediterranean Basin, intercropping perennial fruit trees with annual crops or aromatic and medicinal plants has attracted growing scientific attention, mainly for its agronomic and ecological benefits (Marotti et al., 2023). However, despite the expanding literature, empirical evidence on the economic performance of these systems remains scarce, particularly under heterogeneous Mediterranean conditions.
The ValMedAlm (VALorization of MEDiterranean ALMond orchards) project addresses this gap by adopting an integrated sustainability framework that jointly considers economic, environmental, and social dimensions in the assessment of intercropping practices in almond orchards across five Mediterranean countries.

Purpose and research questions

This study aims to provide preliminary economic evidence on the adoption of herbaceous intercrops and cover crops in Mediterranean almond orchards during the first years of experimentation. Specifically, it addresses the following research questions:

1. What are the short-term economic effects of different intercropping and cover crop systems in almond orchards?

2. How do local agroecological conditions influence the economic viability of these diversified systems?
3. To what extent can intercropping contribute to income diversification without compromising almond productivity?

Design, methodology, and approach

The study is based on a comparative multi-country analysis of demonstration trials implemented within the ValMedAlm project in Italy, Portugal, Croatia, Israel, and Morocco:

- Italian demo site: in an organic farm in the Licata area that already uses minimum tillage systems, intercropping trials are carried out with Sulla and a mixture of three Medicago spp. (Scutellata, Truncatula, and Polymorpha) with CV Tuono.
- Portuguese demo sites: in three experimental fields, two in Macedo de Cavaleiros and one in Argozelo, at different altitudes (from 584 to 750 m a.s.l.), chickpeas and short-cycle clover are being tested with three almond cultivars (Ferraduel, Ferragnès, Makako).
- Croatian demo site: the trial is taking place on the island of Brač in an orchard with rocky soil rich in skeletons. The interactions of four almond cultivars (Ferragnes, Ferraduel, Ai, Texas) with aromatic plants (sage, immortelle, rosemary) are studied.
- Israeli demonstration site: it is in the North District near Neve Yaar. Almond trees (cv. Matan) are tested with cover crops and at different fertilization rates (using treated wastewater).
- Moroccan demo site: the two experimental trials are located at Azilal (altitude 1,348 m a.s.l. and Taoudjate (440 m a.s.l.), in which Faba bean and Lentil are tested with almond CV like Marcona and Fournatin or with local clones.

Given the strong heterogeneity among experimental sites in terms of climate, soil, orchard structure, cultivars, irrigation regimes, and intercrop species, a harmonised economic assessment methodology was applied.

Experimental areas were identified and measured using GIS tools on updated base maps, allowing precise calculation of the effective surface occupied by almond trees and intercrops. All trials were standardised to a 1-hectare rented almond farm, assuming outsourced mechanised operations and hired labour for manual activities.

Economic analysis was conducted using the GAIA (*Gestione Aziendale delle Imprese Agricole*) farm management software, which enables the construction of reclassified balance sheets, production activity schedules, and profit-and-loss accounts consistent with the Farm Accountancy Data Network approach.

Data collection, analysis, and evidence

Primary data were collected through a shared Excel-based logbook, in which project partners recorded all agronomic operations, inputs, labour use, outsourcing costs, yields, and prices. Additional information on local market prices and labour costs was included to ensure economic comparability.

The analysis focused on key technical, economic, and financial indicators (Table 1) and allowed cross-site and cross-treatment comparisons.

Technical parameters	Economic parameters	Technical indices	Economic indices	Profitability indices
UAA (Utilized Agricultural Area)	**TR** (Total Revenues)	**UAA / AWU** (Labor intensity)	**TR / UAA** (Total Land Productivity)	**NI/UAA** (Net profitability of land)
IUAA (Irrigated Utilized Agricultural	**GTP** (Gross Total Production)	**IUAA / UAA** (Incidence of irrigated	**GSP / UAA** (Gross Agricultural land	**VA/AWU** (Farm labor return)
IA (Intercrop area)	**GSP** (Gross Saleable Production)	**TLH/UAA** (Level of labor use)	**VA/UAA** (net land productivity)	**NI/AWU** (Hourly profitability of farm
TLH (Total Labor Hours)	**NI** (Net Income)		**GSP / AWU** (Agricultural labor	**OI/VS** (Profitability of sales)
EH (Employee Hours)	**OI** (Operating Income)		**CC/SV** (Incidence of direct costs)	
WHS (Working Hours Subcontracting)	**OC** (Ongoing Costs)			
AWU (Annual Work Unit)	**FC** (Fixed Costs)			
	VA (value Added)			
	CC (current Costs)			

Table 1. Technical, economic, and financial efficiency indices derived by using the GAIA software.

Results and implications

Preliminary results confirm that the economic performance of intercropping systems in almond orchards is highly context-specific. In line with previous findings on diversified cropping systems (Rodriguez et al., 2021; Viguier et al., 2021), not all intercrop combinations generate positive short-term economic returns.

In some cases, such as aromatic plant intercropping in Croatia, high-value intercrops significantly contributed to overall farm income, supporting earlier evidence on the economic potential of perennial–annual crop associations in Mediterranean systems (Marotti et al., 2023). Conversely, grain legumes and cover crops often generated negative gross margins due to additional costs and competitive effects, particularly under water-limited conditions, consistent with concerns raised by Alcon et al. (2020).

Overall, the findings highlight that intercropping can represent an effective income diversification and climate adaptation strategy only when crop selection, management intensity, and local environmental

constraints are carefully aligned. Long-term monitoring is required to fully capture potential benefits related to soil fertility, risk reduction, and system resilience.

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