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Deliverable 4.1

Economic Analysis of Almond Production with Intercropping Practices

VALMEDALM: Valorization of **Med**iterranean **Alm**ond orchards through the use of intercropping integrated strategies

Index

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1. Executive Summary

The Task 4.1 of Work Package 4 (VALMEDALM project, PRIMA Foundation, Section 2, Call 2021) concerns the economic analysis of almond production systems integrating intercropping practices across five Mediterranean demo sites: Italy (UNIPA), Portugal (MORE/CNCFS), Croatia (UNIST), Morocco (USMS), and Israel (ARO). The analysis was conducted using a harmonised, FADN-compatible methodology applied through the GAIA software (CREA-PB). Data was collected via a standardised Logbook tool developed by UNIPA and compiled by all project partners. To ensure cross-site comparability, all results were standardised on a per-hectare basis, simulating a reference farm with rented land, hired labour for manual operations, and passive subcontracting for mechanised operations. GIS tools were applied to calculate the effective surface ratio between almond trees and intercrop rows within one hectare of orchard.

Economic balance sheets were produced for all five demo sites covering the 2023–2025 period, with the number of seasons varying by site. Key findings are as follows:

In **Italy** (Fattoria Vassallo, Licata), two forage legume intercrops, Sulla (*Hedysarum coronarium*) and a self-reseeding *Medicago* spp. mix, were evaluated over two seasons (2024–2025). Both treatments recorded positive net incomes in both years, with improving results in 2025 as establishment costs declined. The intercrop component alone remained marginally negative, though the deficit narrowed substantially in the second year.

In **Portugal** (Trás-os-Montes), chickpea intercropping under irrigated and rainfed conditions was assessed over three seasons (2023–2025). Irrigated treatments consistently outperformed rainfed ones. The 2024 season was severely affected by an unseasonal warm wind that damaged flowering at all sites, resulting in near-zero almond yields and negative net incomes across most treatments. Results remained predominantly negative in 2025, reflecting carry-over effects and still-low yields.

In **Croatia** (Island of Brač), four medicinal and aromatic plant (MAP) species (sage, rosemary, immortelle, and lavender) were assessed over three seasons (2023–2025). Results demonstrate the risk-buffering capacity of high-value MAP intercropping: in 2024, when a windstorm destroyed almond flowering entirely, immortelle and lavender sustained strongly positive net incomes. In 2025, all four treatments returned positive results, with immortelle reaching €43,856/ha.

In **Morocco** (Aïn Taoujdate), faba bean and lentil intercropping were assessed over two seasons (2023–2024). In 2023, almond production was not recorded due to a miscommunication with the farmer. In 2024, all treatments returned positive net incomes, with lentil (€1,824/ha) consistently outperforming faba bean (€413/ha) and the control (€306/ha).

In **Israel** (Neve Yaar), cover crop mixtures combined with two fertilisation rates were assessed over three seasons (2023–2025). No-cover-crop treatments consistently outperformed cover-crop treatments in short-term economic terms. However, cover crops provide documented long-term agronomic benefits, including soil nitrogen retention and biodiversity support, that are not captured in single-year income statements.

Overall, the results confirm that the economic viability of intercropping in almond orchards is highly site-specific. High-value aromatic and medicinal plants offer the strongest and most resilient economic returns; forage legumes show a positive trajectory as establishment costs decline; grain legumes can be viable when species are well-matched to local conditions; cover crops represent a long-term investment in soil health rather than a short-term income strategy.

2. Introduction and Objectives

The Task 4.1 constitutes the economic pillar of Work Package 4 within the VALMEDALM project. Its primary objective is to conduct a comparative economic analysis of almond production systems integrating different intercropping strategies, across the five demosites participating in the project: Italy (UNIPA), Portugal (MORE/CNCFS), Croatia (UNIST), Morocco (USMS), and Israel (ARO). The task was officially started at M6 (November 2022) and has been active throughout the entire project duration up to M48.

The economic analysis is designed to assess, for each demosite and for each intercropping variant tested, the main economic indicators of the production activity, including Gross Saleable Production (GSP), Production Costs (PC), Gross Margin (GM), Operating Income (OI), and Net Income (NI). The results are intended to provide a quantitative evidence base for comparing the economic viability of intercropping versus conventional monoculture almond production, across different pedoclimatic and management contexts throughout the Mediterranean basin.

The outputs of Task 4.1 directly feed into Task 4.3 (Integration of sustainability results), where economic indicators are combined with environmental, social, and agronomic dimensions within a Multi-Criteria Decision Analysis (MCDA) framework.

3. Methodology

3.1. Data Collection: the Logbook Tool

Given the heterogeneity of the experimental conditions across demo sites – in terms of cultivated area, almond cultivar, intercrop species, farming operations, machinery, type of organisation (commercial farm vs. experimental station), and water management regime – a dedicated data collection instrument was developed and shared with all project partners.

In January 2023, UNIPA began sharing a preliminary version of this tool, known as the "Logbook," an ad hoc Excel workbook structured into seven thematic sheets (Table 1). The Logbook was finalised in its definitive version in October 2023. Each partner was requested to record, for each experimental year and for each treatment variant:

- all cultivation operations carried out (type, timing, duration, machinery used);
- agrochemical inputs administered (fertilisers, plant protection products, irrigation, quantities and unit costs);
- labour requirements for manual operations (hours per operation, local labour cost);
- subcontracting costs for mechanised operations;
- productions obtained (yields per unit area, for both almond and intercrop);
- market prices or quotations applicable in the local context for each year.

Table 1. Examples of data recording sheets from the VALMEDALM Logbook: Register of Irrigation (top) and Register of Harvest (bottom).

REGISTER OF IRRIGATION

Date (dd/mm/yy)	Field/trial/plot[1]	Crop/Intercrop	Irrigated area (ha)	Volume (cubic metar/tree)	Hours	Source*	Price (€/cubic metar)
15.07.23.	Cr1	Crop/Intercrop	40	0,1	12	rainwater	0,15
01.08.23.	Cr1	Crop/Intercrop	40	0,1	12	rainwater	0,15
18.08.23.	Cr1	Crop/Intercrop	40	0,1	12	rainwater	0,15

REGISTER OF HARVEST

Field trial/plot[1]	Crop/Intercrop	Date		Equipment[4] (brand/model)	Modality[3]	Production[4] (QTS)	Yield	Sale (€
		Start (dd/mm/yy)	End (dd/mm/yy)					
1.1-4.5	Intercrop/Rusmarinus	20.6.2023.	21. 6.2023.	sickle	manual	flower	30 g per tree	
1.1-4.5	Intercrop/Helichrysum	4. 7. 2023.	5. 7. 2023.	sickle	manual	flower	20 g pet tree	1
1.1-4.5	Crop/Almond/cv. Ferragneze	5.9.2023.	6.10. 2023.	Campagnola ALICE 58V	manual and mechanical	fruit	5,2 kg per tree	1
1.1-4.5	Crop/Almond/cv. Texas	5.9.2023.	6.10.2023.	Campagnola ALICE 58V	manual and mechanical	fruit	3,1 kg per tree	1
1.1-4.5	Crop/almond/cv. Ferraduel	5.9.2023.	6.10.2023.	Campagnola ALICE 58V	manual and mechanical	fruit	1,2 kg per tree	1
1.1-4.5	Crop/Almond/cv. Ai	5.9.2023.	6.10.2023.	Campagnola ALICE 58V	manual and mechanical	fruit	2,9 kg per tree	1
1.1-4.5	Intercrop/Salvia	25.4.2023.	25.4.2023.	scissors	manual	flower	40 g per bush	
1.1-4.5	Intercrop/Rosmarinus	10.5.2023.	10.5.2023.	sickle	manual	young stems	50 g per bush	
1.1-4.6	Intercrop/Helichrysum	11.6.2024.	11.6.2024.	sickle	manual	flower	330 g per bush	0
1.1-4.7	Intercrop/Lavandula	11.6.2024.	11.6.2024.	sickle	manual	flower	200 g per bush	

This standardised collection protocol made it possible to process data from structurally different systems through a common accounting framework, ensuring comparability of results across demo sites and experimental variants. All project partners contributed to the Logbook compilation and remained available to provide further clarification on the data supplied.

3.2. Analytical Framework and Tools

The economic balances were drawn up using GAIA (Gestione Aziendale delle Imprese Agricole), a double-entry agricultural accounting software developed by CREA-PB as part of the Farm Accountancy Data Network (FADN) survey project (Figure 1). The use of FADN-compatible software ensures methodological alignment with European farm accounting standards and allows the derivation of a complete set of economic results (value of production, costs, value added, net income) and technical-economic efficiency indices.

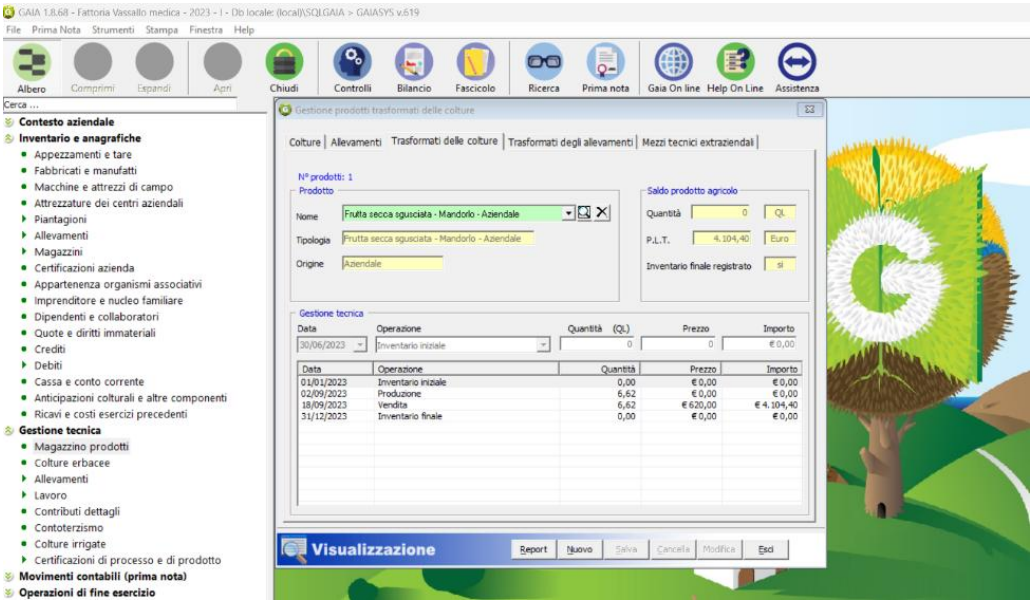


Figure 1. Data entry interface of the GAIA software (CREA-PB, v.6.19).

To ensure comparability between heterogeneous cultivation systems, all data were standardised on a unit basis, simulating a reference farm with:

- a rented area of one hectare of almond orchard;
- a temporary hired labourer for manual operations (paid by hours or days actually performed);
- passive subcontracting for mechanical operations (hourly cost of operations actually performed on-farm).

This approach, inspired by methodological precedents in comparable intercropping studies (Mercenaro et al., 2014), allows the exclusion of pluriennial fixed costs (depreciation, family labour valuation) that would otherwise introduce distortions when comparing real farms with experimental stations or orchards at different production stages.

GIS tools were applied in combination with updated plot maps to calculate, for each experimental trial, the actual surface ratio between almond trees and the intercrop rows within one hectare of orchard Figure 2). This GIS-based approach is essential for accurately attributing production values, yields, and costs to the respective crops within mixed-species systems.

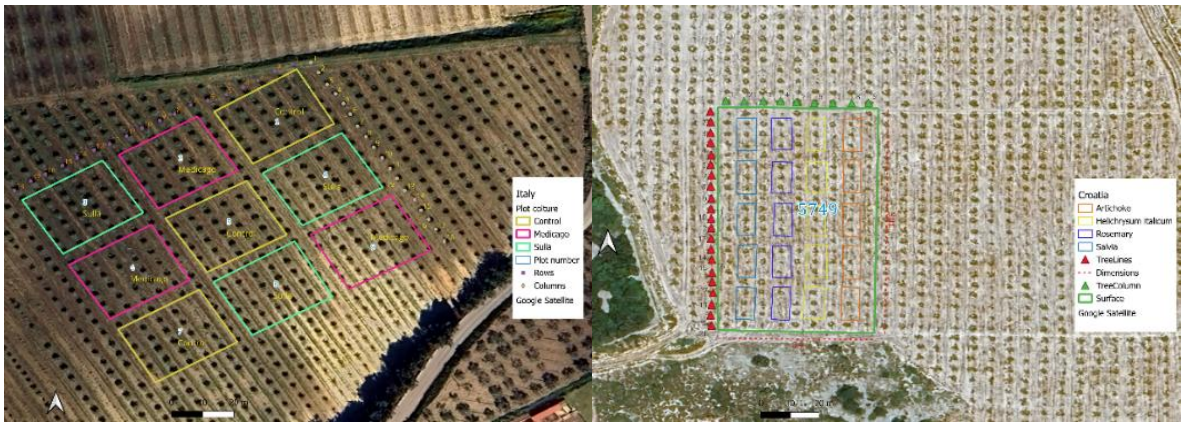


Figure 2. GIS-based plot mapping of the Italian (left) and Croatian (right) demosites, used to calculate the effective surface ratio between almond trees and intercrop rows within one hectare of orchard.

3.3. Structure of Economic Results

For each demosite and each treatment variant, the following economic parameters were calculated on a per-hectare basis:

- Gross Saleable Production (GSP): total value of almond and intercrop output at local market prices;
- Production Costs (PC): total costs incurred, including seed/plant material, fertilisers, crop protection products, water and energy, third-party services, and labour;
- Ongoing Costs (OC, expressed as a percentage of PC): the share of current costs over total production costs;
- Operating Income (OI = GSP − PC): the difference between gross production value and total costs;
- Net Income (NI): operating income adjusted for extraordinary management items;
- Gross Margin per crop (GM = GSP − PC, calculated separately for almond and intercrop).

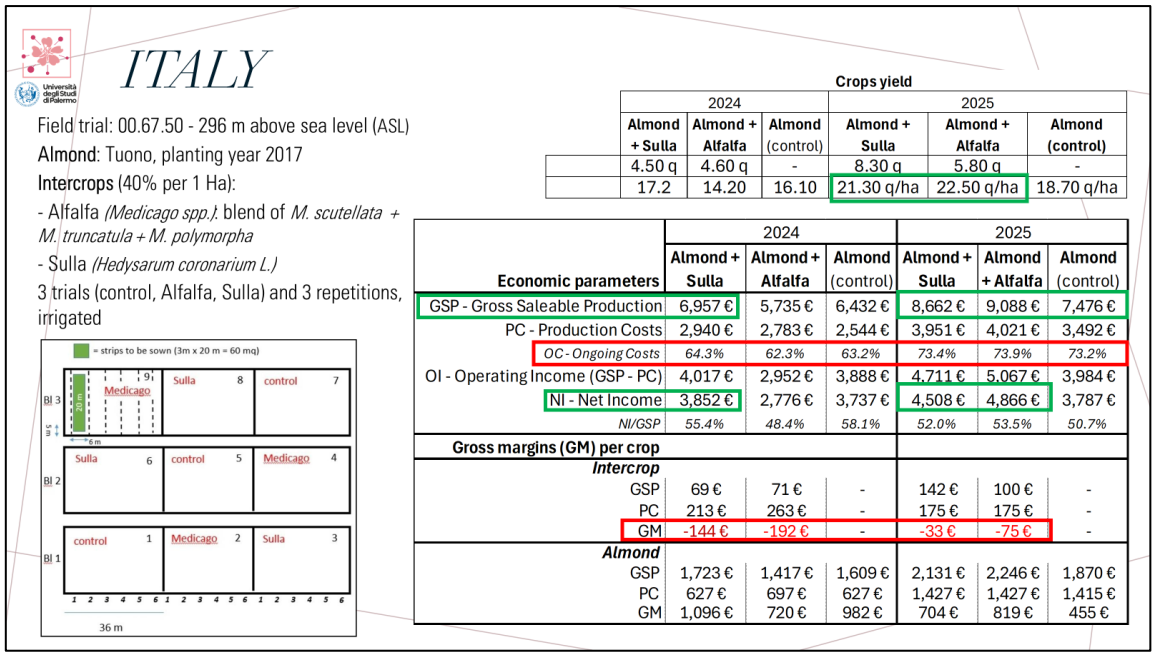
4. Results by Demosite

4.1. Italy – Fattoria Vassallo, Licata (AG) – UNIPA (Figure 3)

Demosite characteristics: The Italian demosite is located at the organic farm “Fattoria Vassallo” in the Licata area (Province of Agrigento, Sicily), at approximately 296 m a.s.l. The almond cultivar is Tuono (planting year 2017), managed under minimum tillage practices. Two intercropping treatments are under evaluation: (i) Sulla (*Hedysarum coronarium* L., biennial legume) and (ii) a self-reseeding mixture of three annual Medicago spp. (*M. scutellata*, *M. truncatula*, *M. polymorpha*), referred to as “Alfalfa” in the Logbook. Both intercrops cover approximately 40% of one hectare. A bare-soil control plot is maintained for comparison. Experimental activities started one year behind schedule due to delays in the receipt of project funding at the national level; the first sowing was carried out in late November 2023, making the 2023/24 agricultural season (hereafter 2024) the first effective cultivation cycle.

Economic results: In 2024, the Sulla treatment recorded the highest net income (€3,852/ha; GSP €6,957, PC €2,940), followed by the control (€3,737/ha; GSP €6,432, PC €2,544) and the Medicago/Alfalfa treatment (€2,776/ha; GSP €5,735, PC €2,783) (Fig. 4). Both intercrop treatments

show negative gross margins for the intercrop component (Sulla: -€144/ha; Alfalfa: -€192/ha), as intercrop revenues did not yet cover seeding and management costs in the first year. The almond component, by contrast, generated positive gross margins across all treatments. In 2025, farm income improved substantially across all treatments: Sulla reached €4,508/ha (GSP €8,662), Alfalfa €4,866/ha (GSP €9,088), and the control €3,787/ha (GSP €7,476). The improvement in the intercrop gross margin is notable – Sulla: -€33/ha; Alfalfa: -€75/ha – reflecting the absence of re-seeding costs (Sulla is biennial; Medicago self-reseeds) and higher almond yields in 2025. Ongoing costs as a share of GSP remained in the 62–74% range across all treatments and years.



Crops yield

	2024			2025		
	Almond + Sulla	Almond + Alfalfa	Almond (control)	Almond + Sulla	Almond + Alfalfa	Almond (control)
	4.50 q	4.60 q	-	8.30 q	5.80 q	-
	17.2	14.20	16.10	21.30 q/ha	22.50 q/ha	18.70 q/ha

	2024			2025		
Economic parameters	Almond + Sulla	Almond + Alfalfa	Almond (control)	Almond + Sulla	Almond + Alfalfa	Almond (control)
GSP - Gross Saleable Production	6,957 €	5,735 €	6,432 €	8,662 €	9,088 €	7,476 €
PC - Production Costs	2,940 €	2,783 €	2,544 €	3,951 €	4,021 €	3,492 €
OC - Ongoing Costs	*64.3%*	*62.3%*	*63.2%*	*73.4%*	*73.9%*	*73.2%*
OI - Operating Income (GSP - PC)	4,017 €	2,952 €	3,888 €	4,711 €	5,067 €	3,984 €
NI - Net Income	3,852 €	2,776 €	3,737 €	4,508 €	4,866 €	3,787 €
NI/GSP	*55.4%*	*48.4%*	*58.1%*	*52.0%*	*53.5%*	*50.7%*
Gross margins (GM) per crop						
Intercrop						
GSP	69 €	71 €	-	142 €	100 €	-
PC	213 €	263 €	-	175 €	175 €	-
GM	-144 €	-192 €	-	-33 €	-75 €	-
Almond						
GSP	1,723 €	1,417 €	1,609 €	2,131 €	2,246 €	1,870 €
PC	627 €	697 €	627 €	1,427 €	1,427 €	1,415 €
GM	1,096 €	720 €	982 €	704 €	819 €	455 €

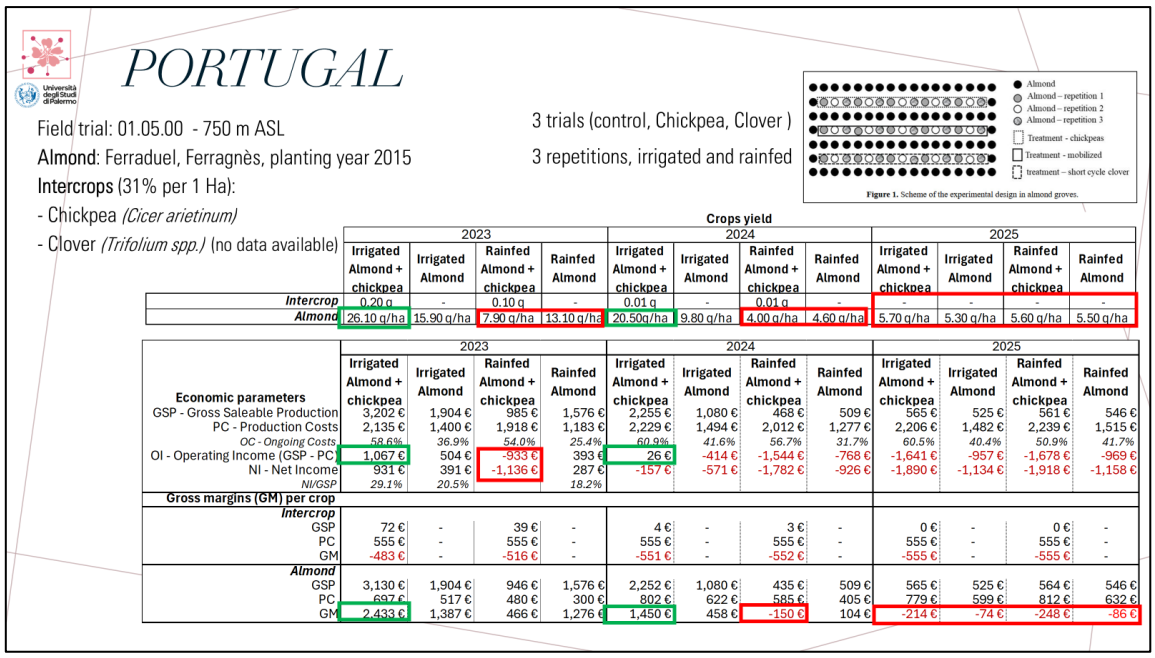
Figure 3. Economic results of the Italian demosite (Fattoria Vassallo, Licata): crop yields and economic balance sheet by treatment (Almond + Sulla, Almond + Alfalfa, Almond control) for the 2024 and 2025 production seasons.

4.2. Portugal – Macedo de Cavaleiros and Argozelo (CNCFS / MORE) (Figure 4)

Demosite characteristics: The Portuguese demosite is located in the Trás-os-Montes region at approximately 750 m a.s.l. The almond cultivars tested are Ferraduel and Ferragnès (planting year 2015). Two intercrops are evaluated: chickpea (*Cicer arietinum*, 31% of one hectare) and short-cycle clover (Trifolium spp., no data available for the clover treatment). The experimental design includes three trials (control, chickpea, clover), each with three replicates, under both irrigated and rainfed conditions.

Economic results: The analysis covers three seasons. In 2023, the irrigated almond + chickpea treatment recorded the best performance: GSP €3,202, PC €2,135, NI €931/ha, with a NI/GSP ratio of 29.1% (Fig. 5). The irrigated almond control returned NI €391/ha. Under rainfed conditions, the chickpea treatment recorded a net loss of -€1,136/ha, while the rainfed control yielded a modest NI of €287/ha. The chickpea intercrop component consistently showed negative gross margins (around -€483 to -€516/ha) in all variants, as seed and management costs were not offset by the low yields obtained. In 2024, a warm spring wind severely damaged flowering at all sites. Irrigated almond + chickpea recorded near-break-even results (NI -€157/ha; GSP €2,255), while all rainfed and control plots recorded significant losses (rainfed chickpea NI -€1,782/ha; irrigated control -€571/ha). In 2025, results remain predominantly negative, likely reflecting carry-over effects of the 2024 damage and

still-low almond yields (5.30–5.70 q/ha irrigated; 5.50–5.60 q/ha rainfed). The irrigated almond + chickpea treatment returned NI -€1,890/ha (GSP €565, PC €2,206); irrigated almond control NI -€1,134/ha (GSP €525, PC €1,482); rainfed chickpea -€1,918/ha; rainfed control -€1,158/ha. Across all three seasons, irrigation consistently improves economic outcomes, and the chickpea intercrop has not yet generated a positive gross margin, given the very low yields recorded.



Crops yield

	2023				2024				2025			
	Irrigated Almond + chickpea	Irrigated Almond	Rainfed Almond + chickpea	Rainfed Almond	Irrigated Almond + chickpea	Irrigated Almond	Rainfed Almond + chickpea	Rainfed Almond	Irrigated Almond + chickpea	Irrigated Almond	Rainfed Almond + chickpea	Rainfed Almond
Intercrop	0.20 q	-	0.10 q	-	0.01 q	-	0.01 q	-	-	-	-	-
Almond	26.10 q/ha	15.90 q/ha	7.90 q/ha	13.10 q/ha	20.50q/ha	9.80 q/ha	4.00 q/ha	4.60 q/ha	5.70 q/ha	5.30 q/ha	5.60 q/ha	5.50 q/ha

	2023				2024				2025			
Economic parameters	Irrigated Almond + chickpea	Irrigated Almond	Rainfed Almond + chickpea	Rainfed Almond	Irrigated Almond + chickpea	Irrigated Almond	Rainfed Almond + chickpea	Rainfed Almond	Irrigated Almond + chickpea	Irrigated Almond	Rainfed Almond + chickpea	Rainfed Almond
GSP - Gross Saleable Production	3,202 €	1,904 €	985 €	1,576 €	2,255 €	1,080 €	468 €	509 €	565 €	525 €	561 €	546 €
PC - Production Costs	2,135 €	1,400 €	1,918 €	1,183 €	2,229 €	1,494 €	2,012 €	1,277 €	2,206 €	1,482 €	2,239 €	1,515 €
OC - Ongoing Costs	*58.6%*	*36.9%*	*54.0%*	*25.4%*	*60.9%*	*41.6%*	*56.7%*	*31.7%*	*60.5%*	*40.4%*	*50.9%*	*41.7%*
OI - Operating Income (GSP - PC)	1,067 €	504 €	-933 €	393 €	26 €	-414 €	-1,544 €	-768 €	-1,641 €	-957 €	-1,678 €	-969 €
NI - Net Income	931 €	391 €	-1,136 €	287 €	-157 €	-571 €	-1,782 €	-926 €	-1,890 €	-1,134 €	-1,918 €	-1,158 €
NI/GSP	*29.1%*	*20.5%*		*18.2%*								
Gross margins (GM) per crop												
Intercrop												
GSP	72 €	-	39 €	-	4 €	-	3 €	-	0 €	-	0 €	-
PC	555 €	-	555 €	-	555 €	-	555 €	-	555 €	-	555 €	-
GM	-483 €	-	-516 €	-	-551 €	-	-552 €	-	-555 €	-	-555 €	-
Almond												
GSP	3,130 €	1,904 €	946 €	1,576 €	2,252 €	1,080 €	435 €	509 €	565 €	525 €	564 €	546 €
PC	697 €	517 €	480 €	300 €	802 €	622 €	585 €	405 €	779 €	599 €	812 €	632 €
GM	2,433 €	1,387 €	466 €	1,276 €	1,450 €	458 €	-150 €	104 €	-214 €	-74 €	-248 €	-86 €

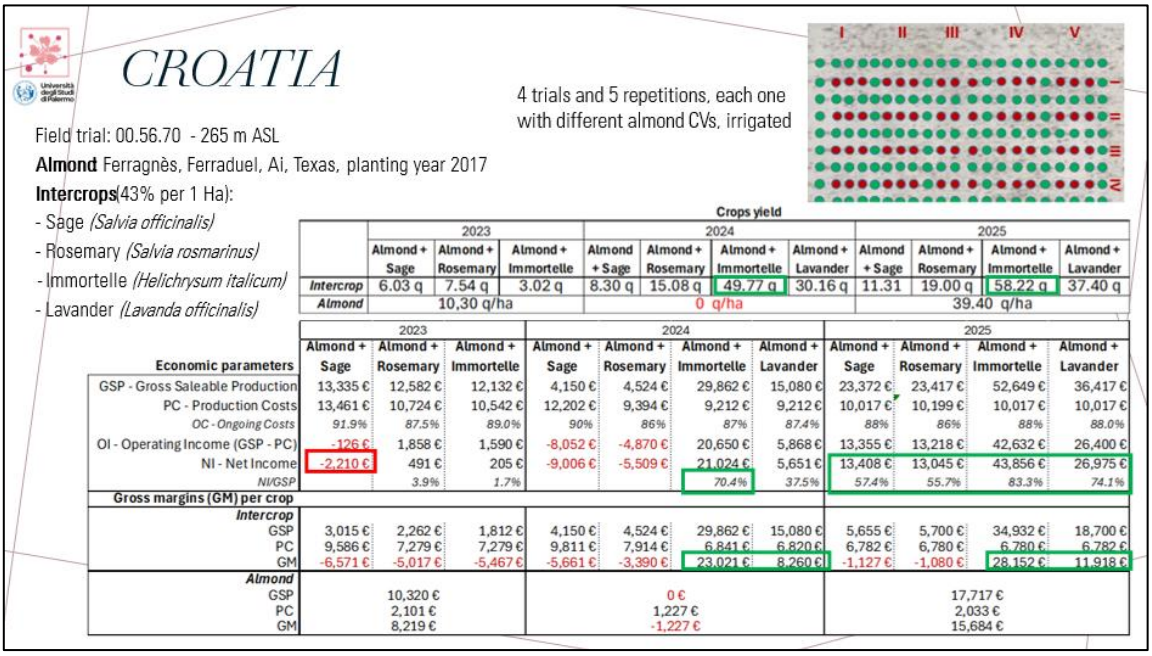
Figure 4. Economic results of the Portuguese demosite (Macedo de Cavaleiros / Argozelo): crop yields and economic balance sheet by treatment (Irrigated Almond + Chickpea, Irrigated Almond, Rainfed Almond + Chickpea, Rainfed Almond) for the 2023, 2024, and 2025 production seasons.

4.3. Croatia – Island of Brač (UNIST) (Figure 5)

Demosite characteristics: The Croatian demosite is located on the island of Brač at approximately 265 m a.s.l. The orchard was planted in 2017 and includes four almond cultivars (Ferragnès, Ferraduel, Ai, Texas). Medicinal and Aromatic plants (MAPs) are tested as intercrops, covering 43% of one hectare: sage (Salvia officinalis), rosemary (*Salvia rosmarinus*), immortelle (*Helichrysum italicum*), and lavender (*Lavandula officinalis*, introduced from 2024). The experimental design comprises four trials, each with five repetitions, under irrigated conditions. Almond yield data were provided as a single average across cultivars rather than broken down by individual cultivar; furthermore, a monoculture almond control was not available.

Economic results: In 2023, almond yield across all treatments was 10.30 q/ha (Fig. 6). The sage treatment recorded a net loss (-€2,210/ha; GSP €13,335, PC €13,461), while rosemary (NI €491/ha; GSP €12,582) and immortelle (NI €205/ha; GSP €12,132) were marginally positive, reflecting high production costs in the establishment phase of the MAPs. In 2024, a windstorm destroyed almond flowering entirely (yield: 0 q/ha), dramatically reducing total farm income. Sage recorded a severe loss (-€9,006/ha) and rosemary (-€5,509/ha), while immortelle (NI €21,024/ha; GSP €29,862) and lavender (NI €5,651/ha; GSP €15,080) showed strongly positive results, driven by their high market value and good intercrop yields. In 2025, almond yields recovered to 39.40 q/ha, boosting overall performance. All four treatments returned positive net incomes: sage €13,408/ha (GSP €23,372), rosemary €13,045/ha (GSP €23,417), immortelle €43,856/ha (GSP €52,649), and lavender

€26,975/ha (GSP €36,417). Production costs were uniform across treatments (€10,017/ha). The Croatian results demonstrate the risk-buffering potential of MAP intercropping: in years with no almond production, high-value intercrops can sustain or generate positive farm income.



Crops yield

	2023			2024				2025			
	Almond + Sage	Almond + Rosemary	Almond + Immortelle	Almond + Sage	Almond + Rosemary	Almond + Immortelle	Almond + Lavander	Almond + Sage	Almond + Rosemary	Almond + Immortelle	Almond + Lavander
Intercrop	6.03 q	7.54 q	3.02 q	8.30 q	15.08 q	49.77 q	30.16 q	11.31	19.00 q	58.22 q	37.40 q
Almond	10,30 q/ha			0 q/ha				39.40 q/ha			

Economic parameters	2023 Almond + Sage	2023 Almond + Rosemary	2023 Almond + Immortelle	2024 Almond + Sage	2024 Almond + Rosemary	2024 Almond + Immortelle	2024 Almond + Lavander	2025 Almond + Sage	2025 Almond + Rosemary	2025 Almond + Immortelle	2025 Almond + Lavander
GSP - Gross Saleable Production	13,335 €	12,582 €	12,132 €	4,150 €	4,524 €	29,862 €	15,080 €	23,372 €	23,417 €	52,649 €	36,417 €
PC - Production Costs	13,461 €	10,724 €	10,542 €	12,202 €	9,394 €	9,212 €	9,212 €	10,017 €	10,199 €	10,017 €	10,017 €
OC - Ongoing Costs	*91.9%*	*87.5%*	*89.0%*	*90%*	*86%*	*87%*	*87.4%*	*88%*	*86%*	*88%*	*88.0%*
OI - Operating Income (GSP - PC)	-126 €	1,858 €	1,590 €	-8,052 €	-4,870 €	20,650 €	5,868 €	13,355 €	13,218 €	42,632 €	26,400 €
NI - Net Income	-2,210 €	491 €	205 €	-9,006 €	-5,509 €	21,024 €	5,651 €	13,408 €	13,045 €	43,856 €	26,975 €
NI/GSP		*3.9%*	*1.7%*			*70.4%*	*37.5%*	*57.4%*	*55.7%*	*83.3%*	*74.1%*
Gross margins (GM) per crop											
Intercrop											
GSP	3,015 €	2,262 €	1,812 €	4,150 €	4,524 €	29,862 €	15,080 €	5,655 €	5,700 €	34,932 €	18,700 €
PC	9,586 €	7,279 €	7,279 €	9,811 €	7,914 €	6,841 €	6,820 €	6,782 €	6,780 €	6,780 €	6,782 €
GM	-6,571 €	-5,017 €	-5,467 €	-5,661 €	-3,390 €	23,021 €	8,260 €	-1,127 €	-1,080 €	28,152 €	11,918 €
Almond											
GSP	10,320 €			0 €				17,717 €			
PC	2,101 €			1,227 €				2,033 €			
GM	8,219 €			-1,227 €				15,684 €			

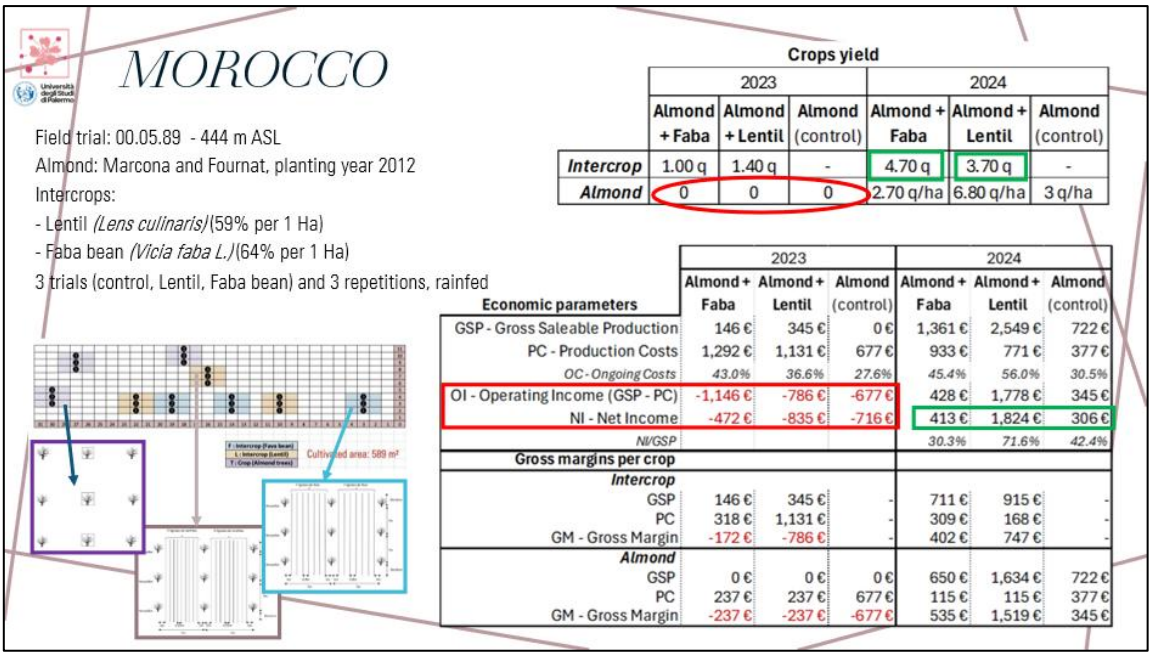
Figure 5. Economic results of the Croatian demo site (Island of Brač, UNIST): crop yields and economic balance sheet by treatment (Almond + Sage, Almond + Rosemary, Almond + Immortelle, Almond + Lavender) for the 2023, 2024, and 2025 production seasons.

4.4. Morocco – Aïn Taoujdate (USMS) (Figure 6)

Demosite characteristics: The Moroccan demosite is located at Aïn Taoujdate (444 m a.s.l.) in the region of Khénifra. The almond cultivars tested are Marcona and Fournat (planting year 2012). Two intercrop species are evaluated under rainfed conditions: faba bean (*Vicia faba* L., 64% of the hectare) and lentil (*Lens culinaris*, 59% of the hectare). Three trials (control, almond + faba bean, almond + lentil) are replicated three times. In 2025, the Moroccan demosite was relocated, making the new experimental conditions not comparable to those of preceding years; the 2025 data were therefore excluded from the analysis.

Economic results: The economic analysis covers two productive seasons (2023–2024) (Fig. 7). In 2023, almond yield data are unavailable for any treatment because the harvest was not recorded due to a miscommunication with the farmer; so, almond production did occur but was not recorded. The intercrop treatments recorded the following results: faba bean NI -€472/ha (GSP €146, PC €1,292); lentil NI -€835/ha (GSP €345, PC €1,131); control NI -€716/ha (GSP €0, PC €677). In 2024, almond yields were recorded in all treatments (faba bean: 2.70 q/ha; lentil: 6.80 q/ha; control: 3.00 q/ha), and all three treatments returned positive net incomes: faba bean €413/ha (GSP €1,361, PC €933); lentil €1,824/ha (GSP €2,549, PC €771); control €306/ha (GSP €722, PC €377). The notably lower production costs in 2024 relative to 2023 reflect the absence of fertiliser and phytosanitary expenditures recorded in the first season. Lentil consistently outperforms faba bean in both intercrop

yield and overall farm income, confirming its greater compatibility with almond under rainfed Mediterranean conditions.



Crops yield

	2023			2024		
	Almond + Faba	Almond + Lentil	Almond (control)	Almond + Faba	Almond + Lentil	Almond (control)
Intercrop	1.00 q	1.40 q	-	4.70 q	3.70 q	-
Almond	0	0	0	2.70 q/ha	6.80 q/ha	3 q/ha

Economic parameters	2023 Almond + Faba	2023 Almond + Lentil	2023 Almond (control)	2024 Almond + Faba	2024 Almond + Lentil	2024 Almond (control)
GSP - Gross Saleable Production	146 €	345 €	0 €	1,361 €	2,549 €	722 €
PC - Production Costs	1,292 €	1,131 €	677 €	933 €	771 €	377 €
OC - Ongoing Costs	*43.0%*	*36.6%*	*27.6%*	*45.4%*	*56.0%*	*30.5%*
OI - Operating Income (GSP - PC)	-1,146 €	-786 €	-677 €	428 €	1,778 €	345 €
NI - Net Income	-472 €	-835 €	-716 €	413 €	1,824 €	306 €
NI/GSP				*30.3%*	*71.6%*	*42.4%*
Gross margins per crop						
Intercrop						
GSP	146 €	345 €	-	711 €	915 €	-
PC	318 €	1,131 €	-	309 €	168 €	-
GM - Gross Margin	-172 €	-786 €	-	402 €	747 €	-
Almond						
GSP	0 €	0 €	0 €	650 €	1,634 €	722 €
PC	237 €	237 €	677 €	115 €	115 €	377 €
GM - Gross Margin	-237 €	-237 €	-677 €	535 €	1,519 €	345 €

Figure 6. Economic results of the Moroccan demo site (Aïn Taoujdate, USMS): crop yields and economic balance sheet by treatment (Almond + Faba bean, Almond + Lentil, Almond control) for the 2023 and 2024 production seasons.

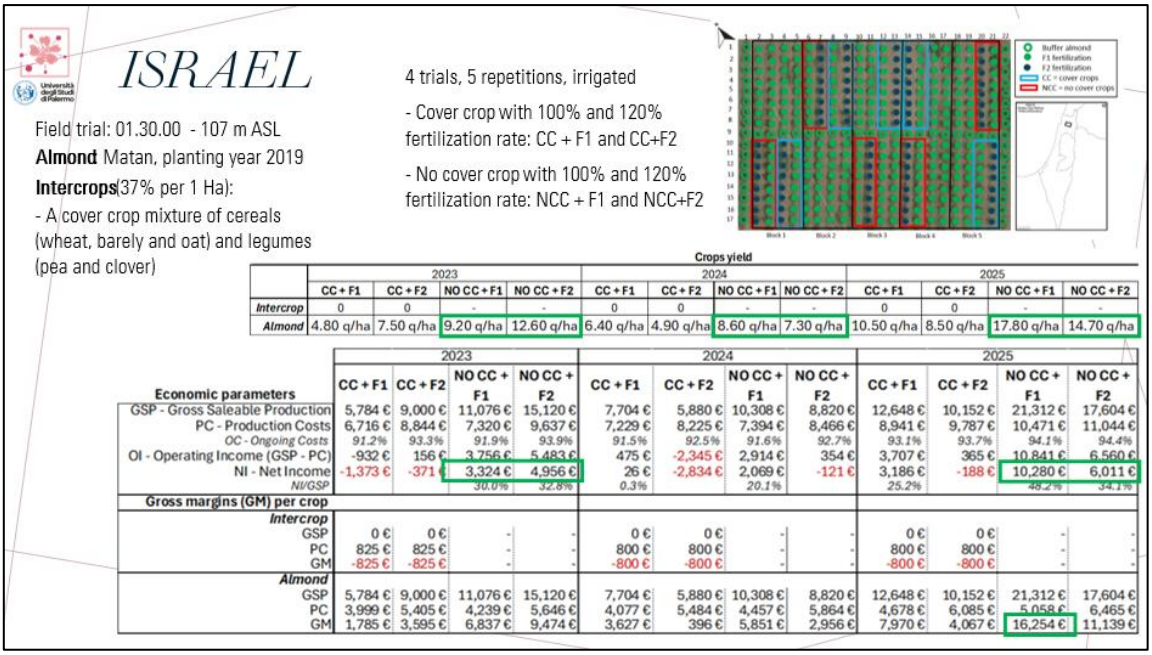
4.5. Israel – Neve Yaar (ARO) (Figure 7)

Demosite characteristics: The Israeli demosite is located at the ARO Model Farm in Neve Yaar (North District, 107 m a.s.l.). A young almond orchard of cv. Matan (planted 2019, spacing 7×6 m) is managed under irrigation with treated wastewater. Four treatment combinations are evaluated: cover crop (CC) vs. no cover crop (NCC), each at two fertilisation rates (F1 = 100%; F2 = 120%). The cover crop mixture (representing 37% of one hectare) comprises cereals (wheat, barley, oat) and legumes (pea, clover). Each treatment includes five repetitions.

Economic results: The cover crop mixture was treated in the economic analysis as a non-marketable crop: it generates no Gross Saleable Production, and its costs are recorded entirely as production expenses. This reflects the actual management of the cover crop, where no harvest or sale of the intercrop biomass takes place.

In 2023, almond yields ranged from 4.80 q/ha (CC+F1) to 12.60 q/ha (NCC+F2) (Fig. 8). The cover crop treatments both recorded negative net incomes (CC+F1: -€1,373/ha, GSP €5,784; CC+F2: -€371/ha, GSP €9,000), while no-cover-crop treatments were positive (NCC+F1: €3,324/ha, GSP €11,076; NCC+F2: €4,956/ha, GSP €15,120). In 2024, almond yields declined across all treatments (CC+F1: 6.40 q/ha; CC+F2: 4.90 q/ha; NCC+F1: 8.60 q/ha; NCC+F2: 7.30 q/ha). CC+F1 remained near break-even (NI €26/ha), CC+F2 recorded a significant loss (-€2,834/ha), while NCC+F1 returned NI €2,069/ha and NCC+F2 remained marginally negative (-€121/ha). In 2025, almond yields recovered strongly (CC+F1: 10.50 q/ha; CC+F2: 8.50 q/ha; NCC+F1: 17.80 q/ha; NCC+F2: 14.70 q/ha). NCC+F1 returned the highest net income across all three years (€10,280/ha; GSP €21,312), followed by NCC+F2 (€6,011/ha; GSP €17,604). CC+F1 recovered to €3,186/ha; CC+F2 remained negative (-€188/ha). Across the three seasons, the no-cover-crop treatments consistently outperform

cover-crop treatments in short-term economic terms. The cover crop component generates no saleable income and imposes direct costs (€800–825/ha), while also depressing almond yields through resource competition. These short-term economic costs must however be weighed against the documented long-term agronomic benefits of cover crops (soil nitrogen retention, biodiversity support, reduced herbicide use).



Crops yield

	2023				2024				2025			
	CC + F1	CC + F2	NO CC + F1	NO CC + F2	CC + F1	CC + F2	NO CC + F1	NO CC + F2	CC + F1	CC + F2	NO CC + F1	NO CC + F2
Intercrop	0	0	-	-	0	0	-	-	0	0	-	-
Almond	4.80 q/ha	7.50 q/ha	9.20 q/ha	12.60 q/ha	6.40 q/ha	4.90 q/ha	8.60 q/ha	7.30 q/ha	10.50 q/ha	8.50 q/ha	17.80 q/ha	14.70 q/ha

	2023				2024				2025			
Economic parameters	CC + F1	CC + F2	NO CC + F1	NO CC + F2	CC + F1	CC + F2	NO CC + F1	NO CC + F2	CC + F1	CC + F2	NO CC + F1	NO CC + F2
GSP - Gross Saleable Production	5,784 €	9,000 €	11,076 €	15,120 €	7,704 €	5,880 €	10,308 €	8,820 €	12,648 €	10,152 €	21,312 €	17,604 €
PC - Production Costs	6,716 €	8,844 €	7,320 €	9,637 €	7,229 €	8,225 €	7,394 €	8,466 €	8,941 €	9,787 €	10,471 €	11,044 €
OC - Ongoing Costs	*91.2%*	*93.3%*	*91.9%*	*93.9%*	*91.5%*	*92.5%*	*91.6%*	*92.7%*	*93.1%*	*93.7%*	*94.1%*	*94.4%*
OI - Operating Income (GSP - PC)	-932 €	156 €	3,756 €	5,483 €	475 €	-2,345 €	2,914 €	354 €	3,707 €	365 €	10,841 €	6,560 €
NI - Net Income	-1,373 €	-371 €	3,324 €	4,956 €	26 €	-2,834 €	2,069 €	-121 €	3,186 €	-188 €	10,280 €	6,011 €
NI/GSP			*30.0%*	*32.8%*	*0.3%*		*20.1%*		*25.2%*		*48.2%*	*34.1%*
Gross margins (GM) per crop												
Intercrop												
GSP	0 €	0 €	-	-	0 €	0 €	-	-	0 €	0 €	-	-
PC	825 €	825 €	-	-	800 €	800 €	-	-	800 €	800 €	-	-
GM	-825 €	-825 €	-	-	-800 €	-800 €	-	-	-800 €	-800 €	-	-
Almond												
GSP	5,784 €	9,000 €	11,076 €	15,120 €	7,704 €	5,880 €	10,308 €	8,820 €	12,648 €	10,152 €	21,312 €	17,604 €
PC	3,999 €	5,405 €	4,239 €	5,646 €	4,077 €	5,484 €	4,457 €	5,864 €	4,678 €	6,085 €	5,058 €	6,465 €
GM	1,785 €	3,595 €	6,837 €	9,474 €	3,627 €	396 €	5,851 €	2,956 €	7,970 €	4,067 €	16,254 €	11,139 €

Figure 7. Economic results of the Israeli demo site (Neve Yaar, ARO): crop yields and economic balance sheet by treatment (CC+F1, CC+F2, NCC+F1, NCC+F2) for the 2023, 2024, and 2025 production seasons.

5. Cross-Site Synthesis and Discussion

The comparative analysis of economic results across the five demosites highlights that the economic viability of intercropping in almond orchards is highly context-dependent. No single intercropping strategy performs uniformly well across all sites; outcomes are shaped by the interaction of pedoclimatic conditions (especially water availability), the commercial value of the intercrop species, the competitive dynamics between almond and intercrop, and local input and output market prices.

In Croatia, the introduction of high-value medicinal and aromatic plants has demonstrated the most robust economic performance, generating positive net incomes even in years without almond production (2024).

In Italy, the forage legume intercropping strategy shows a more modest short-term economic impact (intercrops have not yet generated revenues sufficient to offset their costs), but agronomic contributions (nitrogen fixation, soil organic matter improvement) are expected to yield returns over a multi-year horizon. The improvement between 2024 and 2025, with narrowing gross margin deficits for both Sulla and Medicago, confirms this trajectory.

In Portugal, chickpea intercropping has not yet proven economically advantageous under current management conditions, although it has consistently been associated with better economic outcomes than rainfed monoculture in irrigated trials.

In Morocco, the lentil treatment emerged as the most economically viable option (NI €1,824/ha in 2024), outperforming both faba bean and the monoculture control; both intercrop treatments turned profitable in 2024 after a difficult first season.

In Israel, cover crops impose a short-term yield penalty and a direct cost, but their documented long-term environmental benefits, particularly nitrogen retention and biodiversity, justify continued evaluation within a multi-year framework.

Across all sites, a consistent finding is the high incidence of ongoing costs relative to GSP (ranging broadly from 37% to 94% depending on the treatment and year), underscoring the capital-intensive nature of almond cultivation and the limited margin for intercrop-related cost increments unless offset by sufficiently high commercial returns from the intercrop itself.

6. Contributions of Project Partners

The Task 4.1 was carried out under the leadership of UNIPA, which coordinated data collection, developed and maintained the Logbook tool, processed all data through the GAIA/FADN framework, and produced all economic balance sheets for the five demosites. All project partners actively contributed to the task by compiling the Logbook for their respective demosites and remain available to provide further clarification on the data supplied.

7. Challenges, Deviations, and Corrective Actions

Delayed start of experimental activities at the Italian demosite: Delays in the receipt of project funding at the national level postponed the first sowing to late November 2023, making the 2023/24 season the first effective cultivation cycle. This reduced the number of productive years available for analysis to two (2024–2025).

Data gaps and delayed submissions from partners: Several partners experienced difficulties in providing complete Logbook data within the expected timeframes. The Croatian partner (UNIST) lacks control plot data for all experimental years, which limits direct attribution of intercropping effects to almond yields; furthermore, almond yield data were provided as a single average across cultivars rather than disaggregated by individual cultivar, which constrains varietal-level economic analysis.

Extraordinary events at demosites: In Croatia, a windstorm in spring 2024 destroyed almond flowering entirely, resulting in zero almond yield for that year. In Portugal, an unseasonal warm spring wind in 2024 severely compromised flowering at all three sites, and in 2025 the chickpea intercrop failed to establish, producing no yield. These events affected the completeness of the economic comparison and required appropriate contextualization of results. In Morocco, almond production occurred in 2023 but was not recorded, due to a miscommunication with the farmer; consequently, the 2023 balance sheets for the intercrop treatments reflect only the intercrop revenue component.

Relocation of the Moroccan demosite: In 2025, the Moroccan demosite was relocated, making the new experimental conditions not comparable to those of preceding years. The economic analysis for Morocco therefore covers two seasons (2023–2024) only.

As a corrective measure, UNIPA prioritised the processing of all data received up to M48 and produced economic balance sheets for all demosites for which a sufficient information base was available.

8. Conclusions

The Task 4.1 has produced a comprehensive set of farm-level economic balance sheets for the five VALMEDALM demosites over multiple production years (2023–2025), using a harmonised, FADN-compatible methodology applied through the GAIA software. The analysis confirms that the economic performance of almond intercropping is highly site-specific and depends strongly on the choice of intercrop species, local agroclimatic conditions, and market prices.

The results provide an essential quantitative foundation for the sustainability assessment carried out under Task 4.3. They demonstrate that intercropping can yield economic benefits when designed consistently with local conditions: high-value aromatic and medicinal plants offer the strongest and most resilient economic returns; forage legumes show improving results across seasons as establishment costs decline; grain legumes face economic challenges in water-limited environments but can be viable when species are well-matched to local conditions; cover crops in young orchards impose short-term costs while contributing to long-term soil health and ecosystem services.

The economic balance sheets, together with the methodological framework developed for their production, represent a replicable and transferable tool for the ex-ante economic evaluation of intercropping options in Mediterranean almond production systems.

9. References

Mercenaro, L., Nieddu, G., Pulina, P., & Porqueddu, C. (2014). Sustainable management of an intercropped Mediterranean vineyard. Agriculture, Ecosystems & Environment, 192, 95–104.