Cover Crops and No-Tillage in an Olive Grove (Andalusia, Spain)

Year of issue

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Summary

“La Conchuela” is a commercial olive orchard located about 10 km west of Córdoba, Andalusia, near the A-431 road. Over seven years, it served as a long-term experimental site to assess alternative soil management practices (specifically no-tillage and temporary spontaneous cover crops) to reduce soil erosion and runoff. Results showed that these practices significantly improved soil moisture retention, reduced erosion, and enhanced biodiversity, without compromising yields.

More recent studies confirm and expand these findings. Spontaneous cover crops have been shown to enhance carbon sequestration (up to 642 kg C ha^{-1} yr^{-1}), nutrient retention (N, P, K), and support vegetation diversity. Ongoing research highlights their contribution to maintaining soil organic carbon and resilience under drought conditions, which are increasingly frequent in the Guadalquivir basin. The site is also referenced in broader Andalusian initiatives promoting regenerative olive farming, including the Living Lab Andaluz launched in 2024 to monitor soil health across olive groves in the region.

This case illustrates the long-term viability and scalability of green cover and no-tillage practices in Mediterranean tree crops, especially on rolling terrain vulnerable to erosion.

Photo Gallery



Location

37.815, -4.8980556

Project

NWRM

National ID

Spain_04

Sector

Agriculture

Installation Date

2000-2006

Implementation status

Completed

Contact

Fernanda Milans (IMDEA Water) in close cooperation with José Alfonso Gómez (IAS-CSIC) whose valuable contribution is acknowledged and very much appreciated.

Overview

Location of the project

The case study is located about 10 km west of Córdoba, Andalusia, near the A-431 road.

Country

Spain

NUTS2 Code

Andalucía

Sponge measures implemented in the case study

Minimum tillage

Cover crops

Objectives

Evaluate how different soil management practices could reduce runoff and soil erosion in sloping olive groves under Mediterranean conditions.
Quantify runoff and soil loss under three treatments: no-tillage with herbicide (NT), conventional tillage (CT), and temporary spontaneous cover crops (TSCC). A key goal was to demonstrate that TSCC could lower runoff coefficients to around 1–2%, compared to about 12% under NT. Soil erosion under TSCC was also expected to drop significantly, with values as low as 1.2 t/ha/year observed.
Other objectives included monitoring changes in infiltration, soil moisture, bulk density, and organic carbon. The project also aimed to assess the long-term feasibility of these practices for farmers, ensuring that they did not compromise olive yields.

Involved partners

Authority type	Authority name	Authority role	Comments	Authority responsibility
National water authority	INIA	Financing	National Institute for Agricultural and Food Research and Technology)	Supporting
Research institute / University	IAS-CSIC	Monitoring	Work has been carried out by researchers including J.A. Gómez and co-authors, affiliated with institutions such as IAS-CSIC (Institute for Sustainable Agriculture, part of CSIC, Córdoba)	Responsible

Site Information

Climate Zone

Warm temperate dry

Precipitation

577.00 mm

Temperature (°C)

22.00 °C

Runoff

25.90 mm

Elevation range

144

Slope range

10-15%

Vegetation class

The main vegetation is a commercial olive grove (Olea europaea), managed in rows on sloping terrain. In the inter-row areas, different types of vegetative cover were tested: temporary spontaneous cover crops (TSCC), composed primarily of natural grasses and herbaceous species (e.g., Bromus, Lolium, Trifolium, Avena, Medicago).

WFD Ecological status

Moderate

WFD Chemical status

Failing to achieve good

Design and Implementation

Project scale

Micro

Project scale specifications

This project was implemented on a single experimental olive farm (La Conchuela) near Córdoba, covering a localized area of sloping land. It focused on site-specific soil and water conservation practices, such as cover cropping and no-tillage, with monitoring at the plot and hillslope scale. The interventions and measurements were confined to a field research setting, making it a clear example of a micro-scale natural water retention measure.

Project area

0,029 ha

Area subject to Land use change or Management/Practice change (ha)

0.03 ha

Constraints

Cover crops should be sown in early autumn after the onset of rains. Also the choice of the correct killing date to avoid water competition. They should be mown in early spring in order to prevent competition with the olive tree for water and nutrients. Cover crops can increase the probability of the development of pests an diseases associated to cover crops and increase the probability of wildfires. There are some technical problems related to the seed selection and its maintenance.

Favourable preconditions

The risk of competition for soil, water and nutrients between the tree and the cover crops is minimal in the initial years of the plantation (small and less trees density). Also in the case of irrigated groves that are adequately fertilized.

Financing

Information on Economic costs - income loss

Economic cost of increase in the use of herbicide and application cost

Financing authorities

Authority name	Type of funding	Comments
Autonomous Andalusian Government	Local funds	Through projects CAO 01-001-C4-0, AGR2005- 00595 and AGR2349.
INIA	Private funds	Through project CAO98-15

Compensations

No

Policy and Governance

Policy description

To date, 31% of the olive acreage in Andalusia is located on very steep terrains, on slopes of above 15%; 38% of the acreage is on moderate slopes, in the 7-15% range; the rest on slopes of under 7%. Traditional olive production is based on low tree densities weed control via frequent tillage and canopy size limited by pruning, to ensure the productivity and survival of the plantation in a limited rainfall environment. Olive production in the region has been associated with severe soil erosion problems accompanied by fertility depletion and loss of biodiversity.

Land ownership

The farm "La Conchuela" belongs to Francisco Natera, who has consistently supported the long-term experimental work conducted there.

Policy targets

Runoff control

Erosion Control

Part of a wider plan

No

Public consultation

No

Has contractual arrangements

No

Impacts and Monitoring

Monitoring System

Monitoring requirements

Monitoring was carried out by research teams from Spanish agricultural institutes and universities, focusing on soil, water, and vegetation parameters through regular field measurements.

Monitoring parameters

Throughout the long-term experiments, researchers monitored key hydrological and agronomic parameters including runoff volume, soil loss (erosion), soil moisture, soil organic carbon, bulk density, infiltration, and vegetation cover. Data collection involved installing bounded plots with runoff collectors, measuring rainfall, and assessing soil physical properties annually or seasonally. In more recent studies, they also evaluated aboveground biomass, carbon sequestration, and nutrient (N, P, K) content in spontaneous cover crops. These monitoring activities have provided robust data to evaluate the performance of different soil management strategies in olive groves on sloping land.

Maintenance

Maintenance requirements

The cover crops were maintained by mowing before the dry season, and the no-tillage areas were kept weed-free using herbicides.

Impact Assessment Methodology

Performance impact assessment method

Edge of Field/Plot

Performance impact estimation information

Rainfall, runoff and soil loss were recorded during 7 years under three different soil management systems: no tillage, conventional tillage and cover crops. The results of the three alternatives on soil properties and on runoff and sediment losses were thus compared.

Socio-economic Impacts

Direct benefits information

Economic benefits of improving productivity and avoided cost of improving the soil quality. Economic benefit from reducing tillage (reduce working hours, fuel consumption, machine fix cost).
Regenerative and organic practices on difficult terrains not only improved profitability but also enabled access to financial aid and enhanced environmental stewardship.

Ancillary benefits information

CO2 sequestration, reduction in soil erosion, increase soil and water storage capacity and enhanced biodiversity

Biophysical impacts: Hydrology

Information on retained water

This is still to be defined in co-operation with practitioners. We are working with researchers on soil conservation measures on this water retention potential.

Information on increased water storage

Cover crops increase the infiltration rate and surface storage

Information on runoff reduction

Lower runoff coefficient in the Cover Crop treatment as compared to the Conventional Tillage and No-Tillage treatments. Higher runoff coeficient in the No-tillage system compare to the base line (Conventional Tillage).
Average values (200-2006) runoff coefficient: NT: 11.9% / CT: 3.1% / CC:1.2%

Biophysical impacts: Biodiversity

Improved biodiversity

Yes

Information on improved biodiversity

Changing from bare soil managements (CC and NT) to the use of CC (where the amount of herbicide and frequency of tillage is reduced) increase the biodiversity of the agricultural system (De la Concha et al., 2007). Reducing tillage and heavy herbicide enhance the specturm ground flora and on insect populations. Moreover a permanent grass cover, managed by mowing or grazing, benefits soil and wildlife conservation (Beaufoy, 2001).

Biophysical impacts: Water & Soil Quality

Water quality overall improvements

Positive impact-WQ improvement

Information on water quality overall

In the cover crops treatment the water infiltrated more easily into the soil (under the protective plants) and at the same time the increased flow resistence dissipated the energy of the surface water. The aereal part of the plant intercepted part of the sediment particles carried by the water (Gómez et al., 2009)

Soil quality overall improvements

Positive impact-SQ improvement

Information on soil quality overall improvements

Positive impacto on soil quality under Cover Crops soil management (the capacity of plant covers in intercepting rainfall is a determining factor in the reduction of soil erosion, which subsequently avoids the development of impermeable crusts at the soil surface). No tillage treatment, bare soil with herbicide, does not benefit soil and water conservation compared to the traditional, Convemtional tillage, or the innovative, Cover crop.

Biophysical impacts: Others

Ecosystem impact climate regulation

Impact on GHGs (net emissions and storage) including soil carbon

Information on ecosystem impact climate regulation

Soil carbon sequestration in olives grove derived from the implementation of agricultural practices, mainly by reducing tillage (as in the case of CC management practices) significantly increase by up to 0.3 tons per hectare and year (Rodríguez et al., 2012). Changing from bare soil practices to the use of plant covers in combination with tillage or residual herbicide application, improves soil structure due to an increase in the organic matter (Gómez-Calero et al., 2009) thus allowing for the improvement of the carbon sink capacity of the olive agricultural system.

Information on ecosystem impact GHG soil carbon

Across five paired comparisons in Andalusian olive groves, sites with spontaneous cover crops stored 9.0 to 16.1 Mg C/ha more in the top 15 cm than non-TSCC sites, after more than eight years. In a survey of 46 olive groves, whole-farm cover crops achieved 642.1 kg C/ha/year, with biomass containing substantial N (~19.5 kg/ha/year), P (~2.48 kg/ha/year), and K (~24.3 kg/ha/year).
In broader Andalusian olive orchards, groundcovers plus pruning residues increased SOC by 0.02 to 3.02 Mg C/ha/year over four seasons (to 30 cm depth).

Lessons Learned

Key lessons

The study shows that the use of a cover crop can be a simple, feasible soil and water conservation practice in olive groves on rolling lands in the region. A key factor in its practical use is to establish it early enough to protect the soil in the critical initial years of the grove, when most of the soil is unprotected by the small olive canopy. The no-tillage treatement, bare soil with herbicide, does not benefit soil and water conservation.

Practices are low-cost and compatible with yields
The techniques tested required minimal additional inputs and did not reduce olive yields. Farmers could benefit from reduced fuel use and maintenance, though herbicide costs may rise under no-tillage systems.

Monitoring is essential for understanding impacts
The project’s long-term, well-structured monitoring allowed precise measurement of hydrological and agronomic responses. It also built scientific evidence for wider replication.

No-tillage without cover crops increases risks
Plots with no-tillage but no ground cover (kept bare with herbicides) produced the highest runoff and erosion. This shows that no-tillage alone, without vegetative protection, can have negative impacts.

Barriers

Barrier type	Barrier role
Other	Main barrier

Drivers

Driver type	Driver role
Balancing different objectives	Main driver

Success factors

Success factor type	Success factor role
Specific incentives for stakeholder involvement	Main factor

Transferability

This measure is highly transferable to other sloping Mediterranean olive groves, especially under rainfed conditions. However, success depends on local slope, soil type, rainfall, and how cover crops are managed. Care must be taken to avoid bare soil under no-tillage, and herbicide use should be minimized or replaced by mowing to preserve biodiversity and soil health.

Sources

Sources

Soil management effects on runoff, erosion and soil properties in an olive grove of Southern Spain.

Hydrological and erosive response of a small catchment under olivecultivation in a vertic soil during a five-year period: Implications forsustainability

Application of the water erosion prediction project (WEPP) in olive orchards on Vertic soil with different management conditions

Curve number values for olive orchards under different soil management

The influence of cover crops and tillage on water and sediment yield, and on nutrient, and organic matter losses in an olive orchard on a sandy loam soil

Francia Martínez, J. R., Durán Zuazo, V. H., & Martínez Raya, A. (2006). Environmental impact from mountainous olive orchards under different soil-management systems (SE Spain).

The role of ancillary benefits on the value of agricultural soils carbon sequestration programmes: Evidence from a latent class approach to Andalusian olive groves.

Evaluating the demand for carbon sequestration in olive grove soils as a strategy toward mitigating climate change

Medidas beneficiosas para las aves ligadas a medios agrícola - Sugerencias para su diseño y aplicación en NATURA 2000, en el marco de la programación de desarrollo rural 2007-2013

EU policies for olive farming. Unsustainable on all counts

Carbon Sequestration Through Groundcovers and Pruning Residues in Sustainable Olive Orchards Under Different Edaphoclimatic Conditions

Experimental assessment of runoff and soil erosion in an olive grove on a Vertic soil in southern Spain as affected by soil management

Aboveground Carbon Fixation and Nutrient Retention in Temporary Spontaneous Cover Crops in Olive Groves of Andalusia

Olive Cultivation, its Impact on Soil Erosion and its Progression into Yield Impacts in Southern Spain in the Past as a Key to a Future of Increasing Climate Uncertainty

Exploring the Linkage Between Spontaneous Grass Cover Biodiversity and Soil Degradation in Two Olive Orchard Microcatchments with Contrasting Environmental and Management Conditions

Lateral Transfer of Organic Carbon and Phosphorus by Water Erosion at Hillslope Scale in Southern Olive Orchards