



Transforming **U**nsustainable
management of soils in key
agricultural systems in EU and China

Developing an **i**ntegrated platform of
alternatives to reverse soil degradation

Organic amendments to restore degraded soils



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Short description

Soil degradation, caused by factors such as erosion, compaction, nutrient depletion, and loss of organic matter, severely impacts agricultural productivity and ecosystem health. To combat this, organic amendments like compost, manure, and biochar are increasingly used. These amendments improve soil structure, enhance nutrient content, and promote microbial activity, leading to better soil health and resilience. Integrating organic amendments into soil management practices is a sustainable strategy to restore degraded soils and support long-term agricultural productivity.

Target area

Organic amendments can be applied across diverse climatic regions, soil types, and cropping systems. They are particularly beneficial in regions experiencing soil organic matter depletion, compaction, and nutrient deficiencies. For instance, in dryland agriculture, organic amendments are primarily applied to improve water retention and increase organic matter content, whereas in humid regions, they focus on enhancing soil aggregation and structure. This practice is well-suited for various crop



production systems, including vegetable farming, orchards, cereals, and legumes, where maintaining soil health is essential for long-term productivity.

Problem identification

Soil degradation often results in low soil organic carbon (SOC), leading to reduced fertility and poor structure. Organic amendments help restore SOC by adding organic matter

and enhancing microbial activity. The TUDI Decision Support Tool app (dev-tudi.web.app) app can guide farmers in assessing SOC levels for effective soil restoration.



Fig. 1: Experimental field plots showing different organic amendment applications to assess their effects on soil structure and fertility.

Detailed description of restoration strategy

Organic amendments are an effective strategy to restore degraded soils by enhancing their biological, physical, and chemical properties. Incorporating materials such as compost, animal manure, biochar, and green manure can significantly improve soil organic matter, structure, microbial activity, and nutrient availability. These amendments address soil degradation while supporting sustainable agricultural practices and reducing dependence on synthetic inputs. By integrating organic amendments into soil management, farmers can promote long-term soil health, resilience, and productivity.

- **Compost** is a common organic amendment that enriches soil organic matter, improves structure, and enhances water retention. Made from decomposed organic waste, it provides key nutrients (N,P,K) and promotes beneficial microbial activity, essential for nutrient cycling. Typical application rates range from 10 to 50 tons per hectare, depending on soil and crop needs.
- **Animal Manure** supplies essential nutrients and improves soil organic carbon. Common types include cattle, poultry, and pig manure, each with a unique nutrient profile. Proper composting before application reduces pathogen risks and enhances nutrient availability. Typical rates vary from 20 to 40 tons per hectare, adjusted according to soil tests.
- **Biochar**, produced from pyrolyzed organic materials, enhances soil structure, water retention, and cation exchange capacity.



Fig. 2: Preparation of organic amendments for field application: compost (top) and biochar (bottom).

Especially beneficial in drylands, biochar also promotes microbial activity when combined with compost or manure. Recommended application rates range from 5 to 20 tons per hectare, based on soil texture.

- **Green Manure and Cover Crops**, like legumes (clover, alfalfa) and non-legumes (rye, oats), are grown to improve soil organic matter and reduce erosion. Incorporated during flowering for optimal nutrient content, they act as living mulch, protecting the soil and enriching it with organic material.

Application Techniques vary depending on the amendment type and soil conditions. Compost and manure are commonly broadcast and incorporated into the topsoil using tillage. Biochar can be mixed into planting rows or evenly spread over the field. Green manure crops are grown in place and incorporated through plowing or disking. To optimize the

benefits, it is essential to tailor the application rate and timing to the specific soil degradation problem, crop type, and climatic conditions.

Monitoring and Maintenance are essential to assess the long-term impact of organic amendments. Soil testing before and after application helps determine changes in organic matter content, nutrient levels, and microbial activity. Regular monitoring allows for adjustments in application rates and helps prevent nutrient imbalances. Integrating

organic amendments into a holistic soil management plan ensures sustained improvements in soil health and productivity.

By strategically applying organic amendments, degraded soils can be transformed into productive and resilient systems. The combination of compost, manure, biochar, and cover crops not only restores soil fertility but also contributes to sustainable agricultural practices by reducing dependency on chemical inputs and enhancing soil biodiversity.

Pros/Cons of technique, obstacles to implementation

The main pros of using organic amendments are: i) Improvement of soil fertility and nutrient availability, reducing dependency on synthetic fertilizers; ii) Enhancement of soil structure, reducing compaction and increasing water-holding capacity; iii) Stimulation of soil microbial activity and biodiversity, promoting a healthier soil ecosystem; iv) Long-term benefits for soil health and crop productivity through sustained organic matter input.

However, there are also some drawbacks, such as: i) High initial costs and labor requirements for application and incorporation; ii) Variability in nutrient content and quality depending on the amendment source; iii) Potential risk of nutrient leaching or imbalances if not properly managed; iv) Limited availability and transport challenges in some regions.



Fig. 3: Compost hand-broadcasting on a degraded soil to enhance its soil organic matter content and structure.

Effects/results/case studies

Long-term use of organic amendments has shown substantial benefits in restoring degraded soils, enhancing both soil health and crop productivity. When applied regularly and properly managed, these amendments contribute significantly to soil structure, fertility, and microbial activity.

A 21-year study demonstrated that continuous application of organic-based amendments increased grain yields in rice by 33.4–52.5% and in wheat by 20–42.8%, compared to control groups without organic inputs (<https://doi.org/10.1016/j.fcr.2024.109311>). This yield boost is attributed to improved soil organic matter content and enhanced nutrient availability, which are crucial for maintaining soil fertility in degraded lands.

Moreover, a six-year study on continuous compost application reported maintained soil aggregate stability and increased carbon storage (<https://doi.org/10.1016/j.geoderma.2022.116117>).

These improvements were linked to the increase in soil microbial biomass carbon and dissolved organic carbon, which are critical indicators of restored soil health.

These findings highlight the long-term benefits of organic amendments in degraded soils, emphasizing their role in improving soil structure, increasing organic carbon, and boosting crop productivity, which are fundamental for sustainable agriculture.

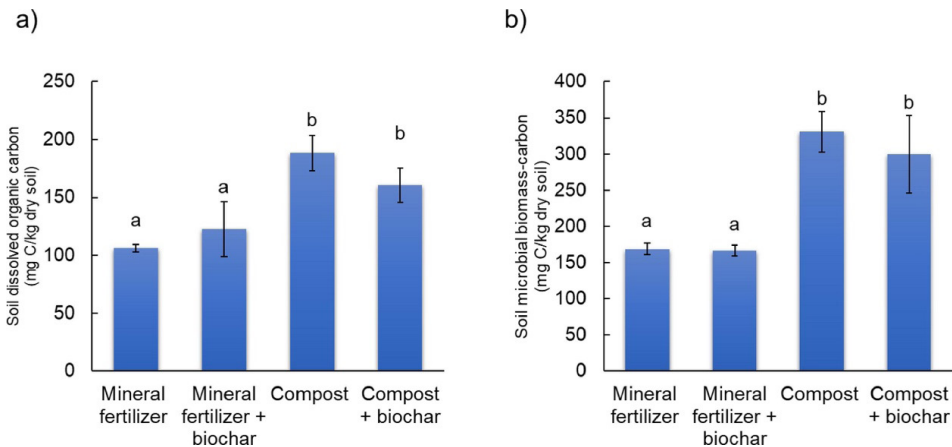


Fig. 4: Soil dissolved organic carbon(a) and soil microbial biomass carbon (b) after 6 years under different management practices (compost and mineral fertilizer; and with or without biochar).

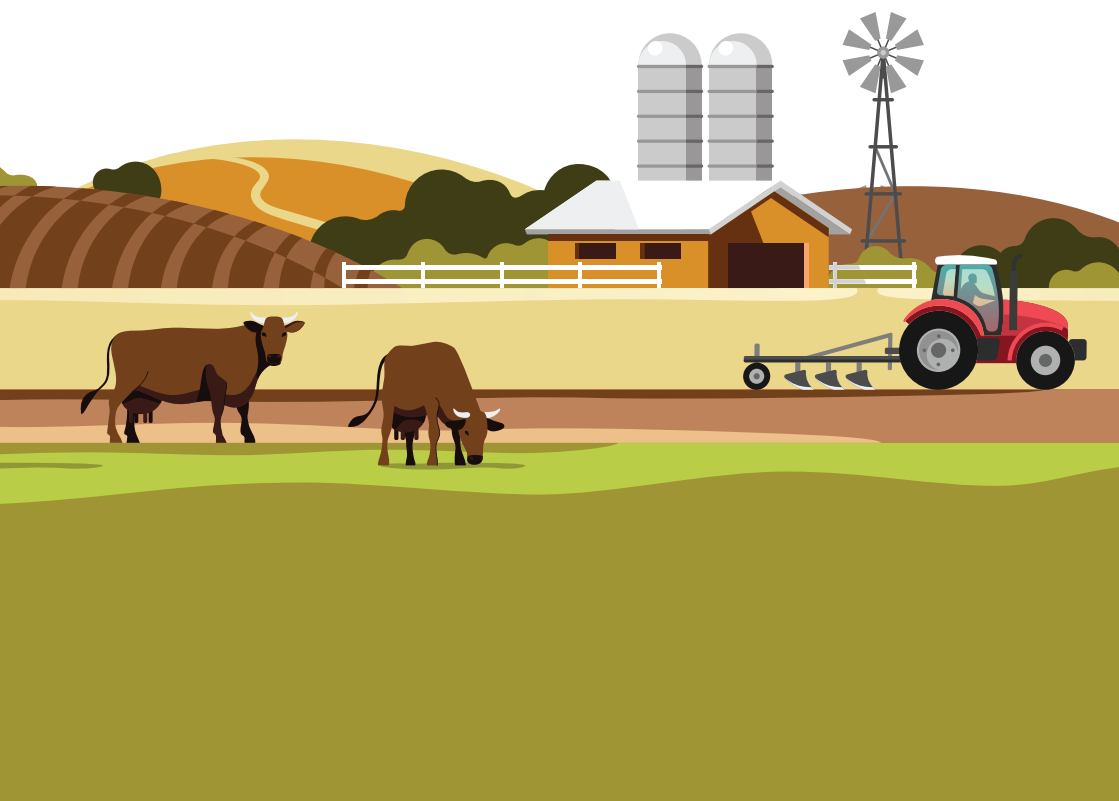


Summary

Organic amendments are a vital strategy for restoring degraded soils. By incorporating materials like compost, manure, and biochar, farmers can promote sustainable agriculture and environmental health. These amendments offer a cost-effective and environmentally friendly alternative to chemical fertilizers, contributing to long-term agricultural sustainability and resilience.

More literature

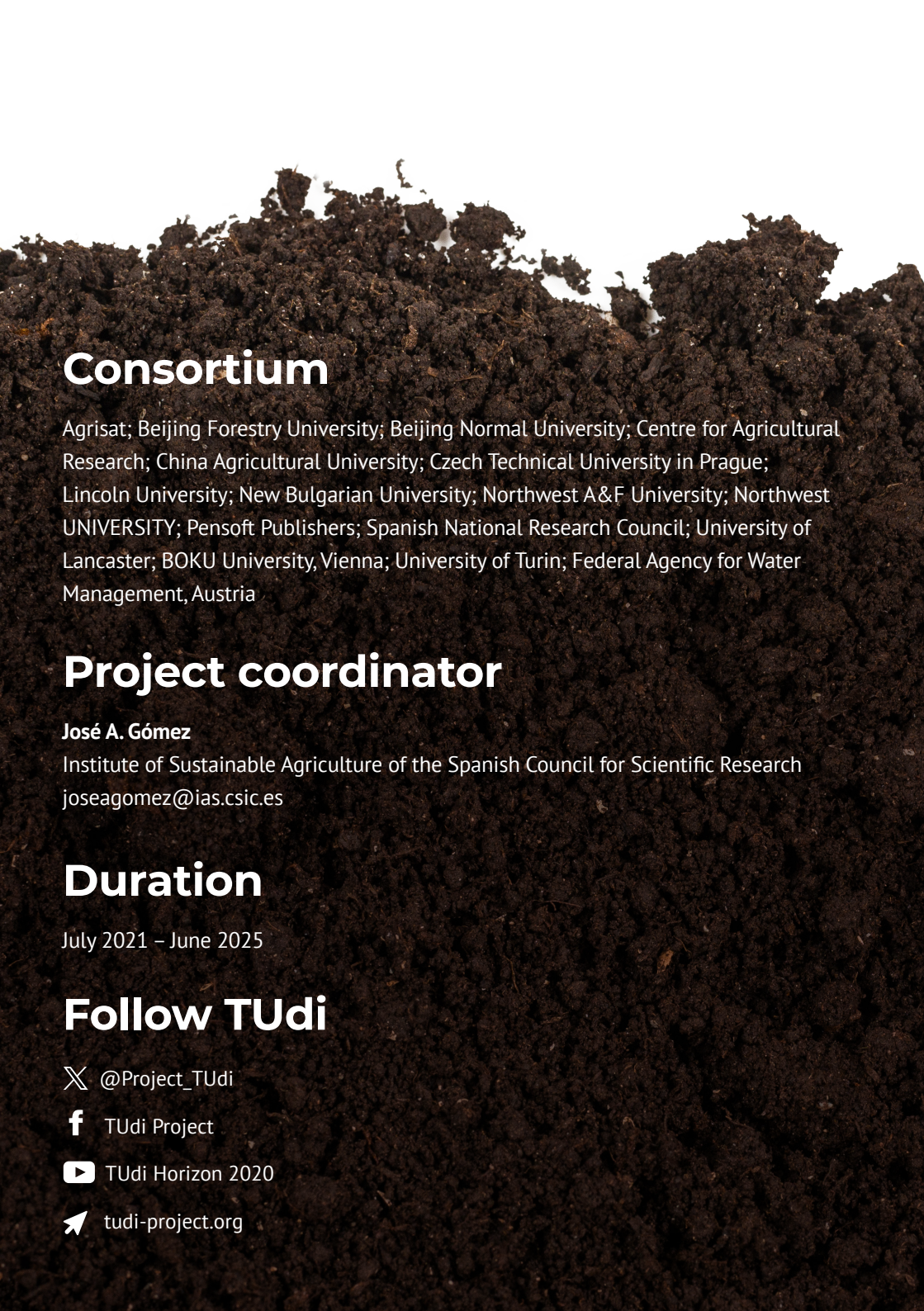
Guidance on soil carbon amendment practices:
<https://www.nrcs.usda.gov/resources/guides-and-instructions/soil-carbon-amendment-ac-336-conservation-practice-standard>



Summary table

	Rating	Comments
Soil health overall	***	Enhances organic matter content and microbial diversity
Water budget	**	Enhances water retention and infiltration
Soil structure	***	Reduces compaction and increases porosity
Erosivity	**	Decreases susceptibility to erosion through improved aggregation
Nutrient balance	**	Increased nutrient availability
Soil life	***	Stimulates beneficial microbial activity.
Practicability	**	Requires proper management and depends on the local availability of organic amendments
Economy	**	Initial costs can be high, but long-term benefits offset expenses





Consortium

Agrisat; Beijing Forestry University; Beijing Normal University; Centre for Agricultural Research; China Agricultural University; Czech Technical University in Prague; Lincoln University; New Bulgarian University; Northwest A&F University; Northwest UNIVERSITY; Pensoft Publishers; Spanish National Research Council; University of Lancaster; BOKU University, Vienna; University of Turin; Federal Agency for Water Management, Austria

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