Subsoiling trials at Orup, Sweden

Year of issue

2025

Summary

At Orup in Skåne, Sweden, SoilCare tested whether loosening a naturally compacted subsoil could improve rooting and yields. The site is a silty sand with high subsoil bulk density and roots seldom below 30 cm. The trial compared three treatments implemented once in autumn 2018: standard practice, subsoiling to the upper subsoil, and subsoiling with straw pellets injected into the 24 to 35 cm layer. A randomized block design with four replicates and 6 × 20 m plots was used. Winter wheat grew in 2019 and sugar beet in 2020. Measurements covered the volume of subsoil affected, root counts by depth, penetration resistance with a 2.5 MPa root-limiting threshold, bulk density and coarse fragments, soil C, N and pH in top- and subsoil, and yields.

Mechanical loosening created distinct subsoil rows. Only 38 to 45 percent of the upper subsoil volume was affected. Straw pellets settled at the bottom of loosened rows rather than mixing. Even so, rooting improved. Maximum rooting depth reached about 35 cm with subsoiling plus straw, compared to about 27 cm in the control. Penetration into the compacted layer increased from roughly 4 cm in the control to about 11 cm with loosening treatments. Despite better rooting, grain and beet yields did not differ significantly at whole-plot scale over two seasons. When results were adjusted for the fraction of subsoil actually affected by the strips, relative yields increased compared to the control.

Stakeholders judged the approach plausible and were interested in learning more, but highlighted barriers. Injecting large amounts of organic material is technically demanding and costly. Advisory capacity and subsidy flexibility matter for adoption. The short-term conclusion is pragmatic. Subsoiling, with or without straw pellets, improved rooting in a naturally compacted subsoil but did not deliver short-term yield gains. Longer-term, repeated treatments, alternative organic materials and multi-site testing are needed to understand agronomic and hydrological benefits.

Photo Gallery





Location

55.8208, 13.5059

Sector

Agriculture

Installation Date

2018

Implementation status

Completed

Contact

SLU

Overview

Location of the project

Orup experimental field site, Skåne County, southern Sweden.

Country

Sweden

NUTS2 Code

Sydsverige

Sponge measures implemented in the case study

Subsoiling

Objectives

Alleviate natural subsoil compaction

Increase rooting depth and reduce penetration resistance

Enable better water and nutrient uptake and potentially improve yields

Involved partners

Authority type	Authority name	Authority role	Comments	Authority responsibility
Research institute / University	Swedish University of Agricultural Sciences (SLU)	Initiation of the measure	Study site leadership, experiment design and monitoring.	Responsible
Farmers	Rural Economy and Agricultural Society	Implementation	Help in site management.	Supporting

Authority type	Authority name	Authority role	Comments	Authority responsibility
Farmers	T. Ingelsson (farmer/consultant)	Determination of design details of the measure	Adaptation of subsoiling equipment. Responsibility: supporting.	Supporting

Site Information

Climate Zone

Warm temperate moist

Precipitation

755.00 mm

Temperature (°C)

8.10 °C

Elevation range

113 m

Vegetation class

Arable land under rotations of barley, winter wheat, oilseed rape and sugar beet.

WFD Ecological status

Moderate

WFD Chemical status

Failing to achieve good

Design and Implementation

Project scale

Micro

Project scale specifications

Micro-scale field trial.

Project area

Total trial area ≈ 1,440 m².

Project area specifications

12 plots, each 6 × 20 m, four replicates across three treatments.

Principles

Mechanical loosening to 35 cm using adapted HE-VA sub-tiller. Straw pellets about 25 Mg ha^{-1} injected behind tines into the 24–35 cm layer. Conventional ploughing to 25 cm for all plots. Penetration resistance critical threshold 2.5 MPa used for interpretation

Factor constraints

Naturally compacted subsoil; roots rarely below 30 cm. Low clay (~10%) limits structural improvement by liming; organic matter inputs considered more promising. Rain-fed system.

Financing

Financing authorities

Authority name	Comments	Financing share
European Union	Horizon 2020 (Research and Innovation). Grant Agreement 677407. SoilCare consortium project.	100 %

Compensations

Non

Policy and Governance

Policy description

Part of the EU H2020 SoilCare project on soil-improving cropping systems.

Target remarks

Mitigate subsoil compaction that restricts rooting and reduces yields.

Pressure remarks

Natural subsoil compaction at >25–30 cm depth.

Part of a wider plan

Oui

Wider plan

Wider plan focus	Name	Comments
Agriculture	SoilCare	Horizon Europe project on agricultural soils

Public consultation

Non

Consultation activities

Activity stage	Activity type	Key issues
Implementation phase	Implementation and results discussion with stakeholders	Unchanged yields, technical difficulty and cost of injecting large organic inputs, need for longer-term and multi-site testing, subsidy flexibility and advisory capacity.

Has contractual arrangements

Non

Impacts and Monitoring

Monitoring System

Monitoring parameters

Randomized block design, 3 treatments, 4 replicates, plot size 6 × 20 m. Measurements: volume of subsoil affected, root counts at depth, penetration resistance, bulk density and coarse fragments, C, N, pH in top- and subsoil, crop yields.

Impact Assessment Methodology

Performance impact estimation information

Field measurements as above, with interpretation against a 2.5 MPa root-limiting threshold. Findings align with broader SoilCare synthesis reporting subsoiling to 35 cm at the Swedish site.

Socio-economic Impacts

Direct benefits

Crop yields of cereals and sugar beet were not significantly affected overall in the short term. When adjusted for the fraction of subsoil actually affected by the strips, relative yields increased compared to the control.

Negative / Other impacts

Topsoil was forced into the subsoil forming distinct rows
Subsoil moved irregularly into topsoil
Straw pellets tended to settle at the bottom of the loosened rows rather than mix through the subsoil
Only 38–45% of the upper subsoil volume was actually affected by subsoiling passes

Biophysical impacts: Hydrology

Information on retained water

Reduced penetration resistance in subsoiling treatments; deeper root penetration (max rooting depth about 35 cm with subsoiling + straw, vs about 27 cm control). No direct infiltration or runoff data reported.

Biophysical impacts: Water & Soil Quality

Information on water quality overall

Top- and subsoil C, N and pH were measured, but no significant water-quality outcomes reported.

Lessons Learned

Key lessons

Short-term mechanical subsoiling, with or without straw, improves rooting but did not significantly raise yields over two seasons. Longer-term, repeated treatments and tests on other soils and crops are needed.

Barriers

Barrier type	Barrier role	Comments
Other	Secondary barrier	Technical difficulty of the injection operation
Other	Secondary barrier	Inflexible subsidy systems and limited advisory capacity reported by stakeholders
—	—	Economic viability of injecting large amounts of organic material

Drivers

Comments
Research need to address natural subsoil compaction limiting root growth and yield.

Success factors

Success factor type	Success factor role	Comments
Attitude of relevant stakeholders	Main factor	Functional advisory system and farmer interest in learning about subsoiling with organic amendments.

Flexibility / Adaptability

Method should be tested over longer time and at other sites; repeated subsoiling and alternative organic materials may change outcomes.

Sources

Sources

Opportunities for Mitigating Soil Compaction in Europe – Case Studies from the SoilCare Project Using Soil-Improving Cropping Systems

SoilCare study site page: Orup, Sweden

Sweden experiment factsheet: “Incorporation of straw into the upper subsoil”

Study Site 13 poster: Orup, Sweden