# Sweden study site experiment: INCORPORATION OF STRAW INTO THE UPPER SUBSOIL

## The problem

Soil compaction is a form of physical degradation is one of eight major soil threats in Europe and has negative consequences for crop yields.

## The proposed solution

The proposed solution was to use mechanical loosening with or without the addition of fresh organic material to achieve improvement in the subsoil. The hypothesis was that loosening and incorporation of organic matter into the subsoil will stimulate biological activity and lead to stabilization of soil structure at a lower density enabling roots to grow deeper. A less compacted soil structure will enable roots to take up more water and nutrients by exploring a greater volume of soil, resulting in higher yields.

The site is located in the southern-most county (Skåne) of Sweden, where the climate is cold temperate and humid. In this area, the subsoil (>25 to 30 cm depth) is naturally compacted, limiting root penetration and thereby nutrient and water uptake from deeper soil layers. Plants rarely root below 30cm in depth.

## Experimental design

The experiment comprised 3 treatments:

A. Control (standard practice with conventional tillage)
B. Subsoiling
C. Subsoiling + straw

The following measurements were taken:

- Volume of subsoil affected
- Visually assessing presence of roots
- Penetration resistance
- Top- and subsoil bulk density, gravel and stones
- Top- and subsoil C, N and pH
- Crop yields

The experimental design was a randomized block trial (6 x 20 m plot size) with four replicates. The subsoiling (to depth of 35 cm) and straw (about 25 Mg $ha^{-1}$ of straw pellets) additions into the upper subsoil layer (24 to 35 cm) was achieved once in the autumn 2018. Straw was pumped from a tank mounted on the front of a tractor and injected through metal pipes behind each vertical tine using an adapted HE-VA sub tiller. Thereafter, winter wheat was grown in 2019 followed by sugar beet in 2020 and fertilized according to local recommendations. All plots were subjected to conventional moldboard ploughing to a depth of 25 cm.

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## Results

A number of unexpected outcomes were identified:

- Topsoil was forced into subsoil forming distinct rows
- Subsoil moved into topsoil irregularly
- Straw was not mixing with subsoil in rows but located at the bottom of subsoil rows together with topsoil
- Volume percentage of the subsoil affected through loosening and straw incorporation varied between 38-45%

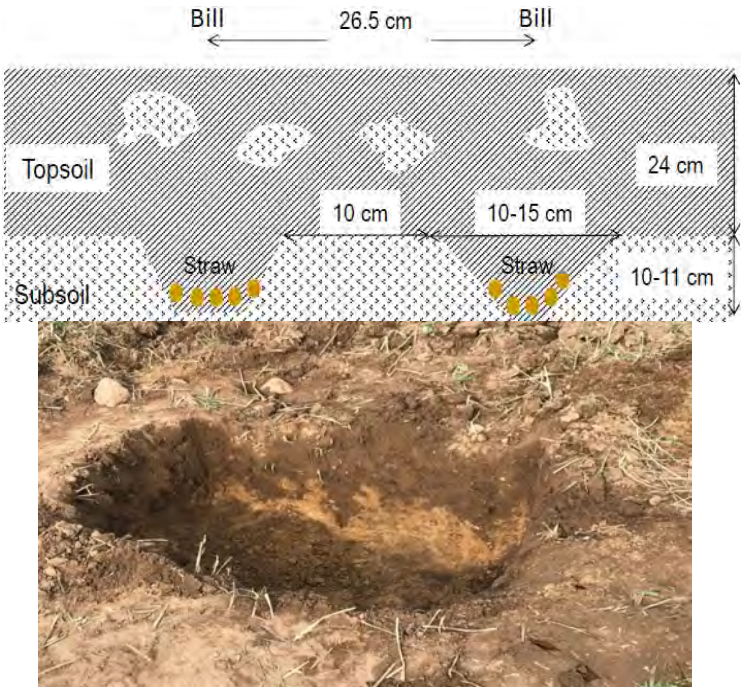


Figure 1 Illustration (top) and photo of a soil profile for evaluation of the effects of subsoiling

Root and penetration resistance data indicated that:

- More roots were present in the subsoiling treatments
- Almost no roots present in the subsoil for the control
- Maximum penetration into the subsoil (>24 cm) was about 4 cm in the control and 11 cm in the subsoiling treatments
- Maximum rooting depth was about 27 cm in the control, 30 in subsoiling alone and 35 cm for the subsoiling + straw treatment

| Treatment | Number of roots along a 10 cm line at various depth | | |
|---|---|---|---|
| | 10cm | 20cm | 30cm |
| Control | 31 | 22 | 3 |
| Subsoiling row | 32 | 54 | 19 |
| Subsoiling + straw row | 63 | 64 | 16 |

Table 1 Presence of roots at various depths. More roots were present in the subsoiling treatments at all depths

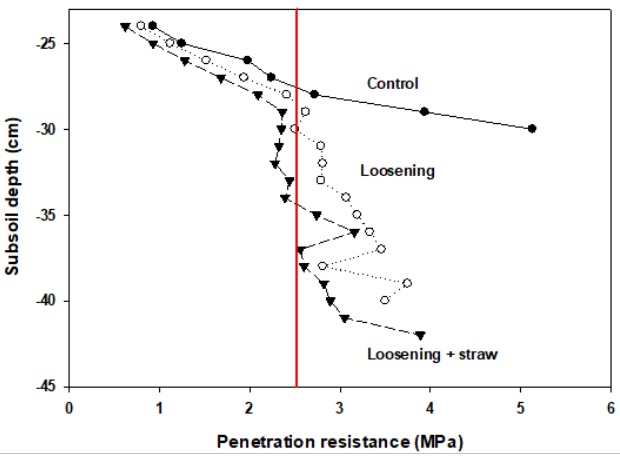


Figure 2. Changes in the penetration resistance upon subsoil loosening and loosening + straw incorporation. The red line (2.5 MPa) indicates the critical limit for root penetration.

Measurements were taken across treatment strips, covering a width of about 40 cm.

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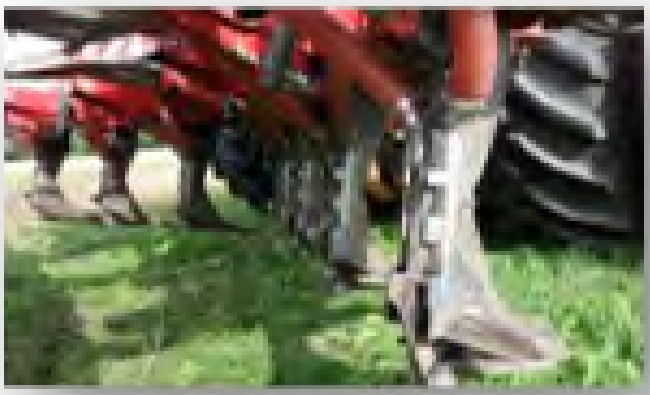
## Results

Crop growth measurements indicated that:

- Yields were not significantly affected by subsoiling
- Subsoiling does not affect the whole hectare but only a portion of the area (distinct subsoil rows) and differs in this sense from other treatments affecting the whole area
- Scaling yield results against the volume percentage of subsoil influenced by subsoiling (using yield of the control as a baseline) increases the effect of subsoiling on relative yields

| Treatment | Portion of affected subsoil | | |
|---|---|---|---|
| | Whole layer | 45 % | 38% |
| Control | 100 | 100 | 100 |
| Subsoiling | 103 | 107 | 108 |
| Subsoiling + straw | 102 | 104 | 105 |

Table 2. Relative yield compared to the winter wheat yield of the control (3220 kg $ha^{-1}$) considering subsoiling treatments were affecting only a portion of the subsoil volume



## Stakeholder feedback

- Farmers were interested in the prospect of using subsoiling and incorporating straw and expressed an interest in learning more
- The results of this study were seen as plausible and aligned with pre-existing knowledge
- It was recognised that a longer-term study is needed to observe significantly beneficial effects of the SICS
- Stakeholders involved in the study were concerned that crop yields were unchanged by the SICS
- Injecting large amounts of organic material may be economically unviable due to technical difficulties and machinery costs
- Participants stated a need to repeat the experiment at other sites to identify how applicable the practice is across various farms.

### Barriers preventing the adoption of straw incorporation

- Inflexible subsidy system which makes it difficult for farmers to experiment or change practices.
- Limited capacity of farm advisors to provide information about these practices.

### Factors encouraging the adoption of straw incorporation

- Well functioning advisory system, thus allowing farmers to make informed decisions



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## Key findings

- Subsoiling affected only a few centimeters of the upper subsoil layer below the topsoil
- There were distinct stripes in the subsoil but 38-45% of the upper subsoil layer was affected
- Straw incorporation during subsoiling did not result in mixing with loosened subsoil
- Rooting characteristics were improved by subsoiling
- The impact of subsoiling on yields of cereals and sugar beets was not significant. However, considering that only subsoil stripes may affect yields, recalculations indicated a positive impact of stripes on yields

## Conclusions

This short-term pilot study on a site with a naturally compacted subsoil showed that subsoiling loosening treatments, with or without the incorporation of straw pellets, have a positive impact on root growth and rooting depths. Subsoiling did not significantly affect yields. However, there is a need for longer-time studies on other crop and soil types, using other sources of organic materials and for examining the effects of repeated subsoil loosening treatments through time.

Stakeholders generally responded positively to the results and expressed interest in the SICS tested here. They did, however, remark that more research on other sites is needed to further assess the applicability of these practices.


## Acknowledgements

We wish to thank T. Ingelsson (farmer and consultant) for his contribution in adapting the subsoiling equipment used in this study.

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## Fact sheet authors


Gunnar Börjesson, Martin Bolinder, Thomas Kätterer, Holger Kirchmann, Jane Mills


## Contact information


Project website: soilcare-project.eu

Study site leader: gunnar.borjesson@slu.se

Project coordinator: Dr. Rudi Hessel, rudi.hessel@wur.nl





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