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SmartSOIL FACTSHEET
BOOSTING ON-FARM SOIL ORGANIC MATTER WITH COVER/CATCH CROPS

WHAT IS IT?

Adding cover/catch crops to crop rotations helps improve soil quality, reduce soil erosion, enhance nutrient cycling and water holding capacity, and as a result, potentially increase crop yields. Cover crops are grown to provide vegetative cover between rows of main crops in orchards and vineyards or between periods of regular production to prevent erosion. They may also function as catch crops, which scavenge the remaining nitrogen after the main crop is harvested, thereby reducing losses from leaching.

WHAT ARE THE BENEFITS?

- Enhance soil quality and health
- Suppress weeds and help control pests
- Reduce inputs, including fertilisers and herbicides and water
- Potential yield improvements

Soil Quality

Timely planting of cover/catch crops, such as clover, rye, or legumes, to otherwise bare soil helps to increase carbon and/or nitrogen levels within the soil, critical to soil quality.(1) Planting cover crops increases soil organic matter (SOM) and thus soil organic carbon (SOC) (see box below). SOM promotes nutrient cycling, which may result in more nitrogen available to plants and less lost through leaching. Overall, soil structure is improved, increasing water retention and infiltration, workability, and reducing soil erosion and fertiliser run-off.

Reduction of Inputs

With effective management, cover/catch crops capture nitrogen within the soil for use by the following main crop and increase water holding capacity. Moreover, nitrogen-fixing crops (e.g., legumes) transfer atmospheric nitrogen into the soil. Fewer inputs of both fertiliser and water may thus be necessary. Cover/catch crops may also provide effective weed and pest control. If tailored to the farming system, where type of cover crop and timing are carefully considered, fewer herbicide and pesticide inputs will be needed. Reduced fertiliser and herbicide/pesticide use presents several on-farm and off-farm benefits, including potential cost-savings, reduced run-off, less impact on biodiversity, and lower risk of soil compaction from field applications.

Soil quality

Soil quality refers to soil attributes, soil functions and to the associated services delivered by soils. The soil quality may be described in terms of chemical, physical and biological properties. These characteristics determine the soils functions in terms of water and nutrient supply to plants as well as providing the physical and biological environment to reduce crop stresses and losses from diseases and pests. Soil quality therefore contributes to a range of ecosystems services that include sustaining crop yield, buffering water, recycling nutrients, reducing emissions of greenhouse gas and pollutants.

Co-benefits

Type of benefit	Size of effect LB	Size of effect NLB	Type of effect
Erosion protection	+	+	Reduced soil erosion and run-off to water bodies (positively impacting water quality)
Prevent nutrient leaching (N, P)	+/0	0	Crop scavenges N from the soil and makes it available for the following crop, contributing to reduced nitrate leaching
Promote soil biodiversity	+	+	Increase in soil organisms and activity
Promote above ground biodiversity	+	+	Provides habitats and potentially enhances biological control of pests and diseases
Reduce soil emissions	+/0	0	Potential reduction in ammonia emissions if managed effectively, although incorporation of the cover crop may also result in nitrous oxide emissions

Legend: ++ maximum positive effect, + positive effect, 0 no effect, - negative effect, -- maximum negative effect
LB: Legume-based cover/catch crop; **NLB**: Non-legume-based cover/catch crop

Potential yield improvement

Cover/catch crops help build SOM particularly over a longer period of time, also positively impacting SOC levels. Therefore, more nutrients (in particular nitrates) will be retained in the soil which will be available for uptake by crops. This may result in yield gains of up to 20% from implementing cover crops (conservative estimates have shown that a 10% reduction is possible as well).

DRAWBACKS

In addition to their impact on the main crop and soil as well as cost-savings from reduced nutrient inputs, cover/catch crops could also potentially be used for livestock fodder and result in cost-savings.
The effect of cover/catch crops on N availability very much depends on the type of crop used and local climatic conditions. In some cases, there are no benefits (or even a negative effect) on crop N availability. For instance, some catch crops may reduce the soil mineral N available in spring compared with having no catch crop. Moreover, the catch crops may be slow in making the N they take up available for the main crop through mineralisation, which may reduce the main crop's yield. Competition for water may also result in some cases between the cover/catch crop and the main crop (e.g., some non-legumes in vineyard rows) rather than enhancing soil moisture through increased soil organic matter, infiltration and shading. Thus, it is important to consult your farm advisor and use a cover/catch crop that is appropriate for your region (also see the SmartSOIL DST for possibilities for your region).

How this measure is implemented is also important, e.g., destruction and incorporation of the cover/catch crop. Timing this to correspond with the main crop's growth period for improved nutrient uptake may help reduce nitrate leaching and nitrous oxide emissions from the soil.

Soil organic carbon (SOC) in soil organic matter (SOM)
SOM is composed of plant residues and microorganisms which breakdown and transform organic materials. This decomposition process produces or modifies SOM and increases SOC stocks in the soil. The process, which removes carbon dioxide from the atmosphere and adds carbon to the soil (via plant photosynthesis and decomposition and transformation), is called soil carbon sequestration. The amount of SOC gained depends on location (due to climate), crop productivity and crop type, amount of roots, crop residue and soil management.

More carbon benefits the formation of soil structure (stable aggregates) and results in: better aeration, more water availability, lower bulk density, friability and improved drainage. These in turn aid soil workability, reduce soil compaction and enhance infiltration capacity, thereby reducing run-off and erosion.

Relationship between SOM/SOC, N fertiliser and water

N fertilisers and irrigation can help SOM (SOC) accumulate through increased crop production (increased organic input to the soil primarily through more root biomass and crop residues). The extent of the effect depends on having appropriate management in place (choice of tillage, cropping system, rotation), soil type, residue quality and on the response to weather and climate. In particular, fertilisation can help SOM accumulate in soils with low SOM levels and in poorly drained soils. Efficient N management is important and can lead to reduced emissions per unit of produce. However, irrigation combined with fertilisation or poorly timed irrigation may increase emissions, particularly of N_2O, and losses of N require additional fertiliser input later on.

Cover crops can affect the need for fertilisers

Catch/cover crops can reduce the need for N fertiliser application by capturing N (which could otherwise be lost through leaching) and making it available to following crops, although this depends on the type of cover crop and local climatic conditions. Using N-fixing cover crop and accumulating SOM through increased below-ground biomass inputs from cover crops also can increase N availability and reduce the need for fertilisers; however, it is possible that more N may be needed in some situations with cover crops to offset N immobilisation.

WHAT ARE THE COSTS?

Implementation costs and cost-savings

Type of costs	Description of costs	Region					
		Denmark Avg (€/ha)	Italy Avg (€/ha)	Hungary Avg (€/ha)	UK Avg (€/ha)	Poland Avg (€/ha)	Spain Avg (€/ha)
Investment costs	Purchase costs of seed	100	138.8	91.5	100	67.3	40.7
Operational costs	Extra passes on the field equipment for sowing and incorporation of the cover crop Additional fuel Increased labour and time to establish the crop	22	30	21	22	21	0
Other costs	Loss of production due to e.g. displacing winter crops for spring crops	78.2	427.3	0	137.8	0	0
Cost-savings	Reduced inputs, e.g. less fertiliser and/or pesticide	0	0	0	0	0	-25.5
Total		**200.2**	**596.1**	**112.5**	**259.8**	**88.30**	**15.2**

Calculations are based on data from EU Member States (FADN, SmartSOIL case studies, Natural Water Retention Measures project, 2014)

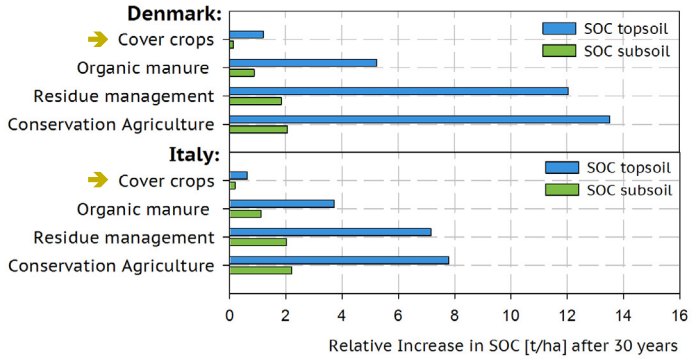
Impact on gross margin

Generally, gross margin will be reduced by the investment and operational costs incurred (i.e., seeds and planting/incorporation costs). In addition, there could be very high costs associated with switching spring crops to winter production, for example. However, savings can be made on reduced inputs and higher crop revenues from yield improvements (see example below and the Real-Life Cases in the SmartSOIL Toolbox). It is important to note that the estimates in the table above are general for the case study regions.

Long-term yield impacts, due in part to enhanced soil, could outweigh the costs of establishing the cover/catch crops and should be considered in the farm's long-term strategy.

In determining average values for the EU, gross margin impacts depend on whether high, middle or low yield scenarios are considered. The range of outcomes shows that adding cover/catch crops may increase gross margin by 16.60 €/ha or decrease gross margin by 270 €/ha, but on average it is estimated that gross margin in the short term will decrease by 174.50 €/ha.The percentage change in gross margin depends on whether the cover/catch crop is implemented during the winter or spring, what kind of crop is used (e.g., legume, rye) as they may have varying yield impacts, and the region under consideration. Consulting with a farm advisor to carefully select a cover/catch crop appropriate for your operation is recommended.

IMPACT ON SOC AND NITROGEN INPUT



	Denmark	Italy
SOC (0-100 cm) [t C/ha]	1,4 (1,6%)	0,8 (1,2%)
Productivity [t/ha]	0,03 (0,3%)	0,01 (0,2%)
Optimal N-rate [Kg N/ha]	-1 (0,8%)	-1 (1,1%)
Need for N-input [Kg N/ha]	-1,0	-1,4

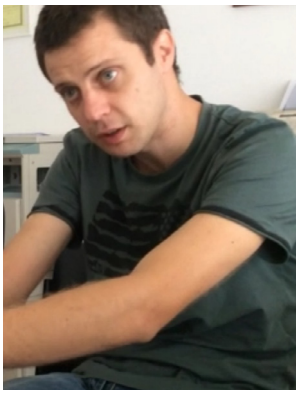
*The SmartSOIL Simple Model shows that implementing **cover crops** increases topsoil SOC levels over 30 years. However, the graph shows that even higher levels of SOC can be achieved by adding manure or retaining crop residues and the highest by combining the practices under conservation agriculture. The table gives an overview on **changes** which are expected from the implementation of cover crops (compared to the reference scenario/ business as usual) using the regional examples of Denmark and Italy. Gains in SOC from incorporating cover crops can be observed in both regions. Small productivity increases may result, but importantly, less N input would be necessary. The optimal N rate is lower when implementing cover crops, which means the N level where the highest yield is achieved decreases and adding more N will not increase the yield response. In consequence, costs can be saved through lower N input. It is important to consider that the impacts vary among the regions according to their specific conditions.*

WHAT DO FARMERS SAY?

Farmer from Tuscany, Italy
Farm system: Arable Land, Mixed Crops (wheat, sunflower, maize, soya)
Farm size: 300 ha (Medium Farm)

MARTELLO NADIA FARMS

"Integrating conservation practices is not difficult. Nevertheless, a testing phase over small fields is necessary.



What are the benefits you have gained from using this practice?
My soil organic matter has increased in a variety of soil types and I have experienced economic gains from improvements in yields. Also although cover crop operations and seeds have increased my costs, these are off- set by significant savings on fertiliser costs, as well as a reduced need for deep ploughing on my fields. Crop diversification has also helped make the business more resilient.

What challenges have you faced in using cover/catch crops?
I have had to overcome some technical barriers through trial and error, such as how to adequately prepare the soil before planting, which is the best time to plant, and when to leave the previous cover crop on the ground (for integration into the soil).

FURTHER READING

(1) RDP Fiche M2: Cover crops/reducing bare fallow – MITIGATION in Annex I. Frelih-Larsen, A., MacLeod, M., Osterburg, B., Eory, A.V., Dooley, E., Kätsch, S., Naumann, S., Rees, B., Tarsitano, D., Topp, K., Wolff, A., Metayer, N., Molnar, A., Povellato, A., Bochu, J.L., Lasorella, M.V., Longhitano, D. (2014) "Mainstreaming climate change into rural development policy post 2013." Final report. Ecologic Institute, Berlin.
(2) Mallast, J., Rühlmann, J., Verhagen, J., ten Berg, H. (2014) Compatibility of Agricultural Management Practices and Types of Farming in the EU to Enhance Climate Change Mitigation and Soil Health: Overview of technological innovations in soil management. Deliverable 4.451 of the FP7 Catch-C project.
(3) Opportunities for cover crops in conventional arable rotations. AHDB Information Sheet 41, http://cereals.ahdb.org.uk/media/655816/is41-opportunities-for-cover-crops-in-conventional-arable-rotations.pdf.

For more detailed information about the practice implemented, benefits, and economic data, please refer to the Real-Life Cases in the SmartSOIL Toolbox:
http://smartsoil.eu/smartsoil-toolbox

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