POLICY BRIEF

SOIL AND CROP MANAGEMENT PRACTICES FOR CLIMATE ADAPTATION

EJP SOIL
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INTRODUCTION

Soil management and cropping systems enhancing soil structure are key to support the sustainable adaptation of EU agriculture to climate change. The occurrence of extreme weather events, such as drought in summer and floods in winter, will increase almost everywhere in the EU. Guidance on management practices to help farmers adapt to these situations is necessary. Many practices exist and have already been subject to scientific research for several decades. Nevertheless, it is not always clear which practices have really proven effective in which contexts, what trade-offs have to be taken into account and which synergies might occur.

We investigated the implications of agricultural management practices for soil hydrological functioning under European agro-environmental conditions as a part of the European Joint Partnership Soil. We synthesized the results of 36 selected meta-analyses[1] (representing data from 2803 unique studies) studying the impact soil and crop management practices on soil hydrological functioning. As such, we identified the effectiveness of the selected practices, and also remaining knowledge gaps. Important trade-offs and synergies related to crop production, water quality, and greenhouse gas emissions were also assessed based on the results of additional published meta-analyses. **This information is crucial to decide which actions to stimulate through policy instruments.**

[1]A meta-analysis is a statistical analysis that combines the results of multiple scientific studies.

WHAT NEEDS TO BE DONE?

Incentivize the implementation of a year-round soil cover with financial help and/or legislation.

Make sure organic matter from agricultural activities stays or returns as much as possible to the field and encourage addition of organic amendments.

Reward a reduction of traffic on agricultural land rather than focus only on a reduction of tillage.

EFFECTIVE AGRICULTURAL MANAGEMENT PRACTICES FOR CLIMATE ADAPTATION

Throughout the EU, farmers, industry and governments are dealing with the impacts of climate change on agriculture. In 2018 in Flanders, for example, the government paid almost 150 million EUR to redeem farmers affected by the drought. Although the importance of soil in agricultural production is clear, the role of the soil in adaptation to climate change has not received much attention.

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The ecosystem services a soil can deliver, and therefore its potential as a climate adaptation tool, depend profoundly on its structure, i.e. the physical arrangement of the soil pore space. Mediated by various biological (e.g. faunal and microbial activity) and physical processes (e.g. traffic compaction, wet-dry and freeze-thaw cycles), soil structure is constantly evolving, driven by climatic factors as well as agricultural management practices. In turn, soil structure strongly affects all life in soil and the hydrological processes that determine the water fluxes in and out of the soil and plants. Thus, adopting soil and crop management practices that enhance soil structure is a key way to support the sustainable adaptation of EU agriculture to climate change by maintaining agricultural production in the face of increasing drought or water excess, without impairing environmental quality.

The effects of soil and crop management practices on soil hydrological functioning have been studied in many long-term field trials throughout the world. In addition to narrative reviews, many quantitative meta-analyses synthesizing the findings of individual experiments have also been published. However, a significant knowledge gap remained concerning the water regulation function of soil, specifically water infiltration and storage in soil and supply to crops. In this study, we focus on the implications of agricultural management practices for soil hydrological functioning for climate change adaptation, specifically under European agro-environmental conditions. We synthesized the results of 36 selected meta-analyses studying the impact soil and crop management practices on soil hydrological functioning.

SPOTLIGHT ON THREE PRACTICES

There is considerable degree of consensus on the effects of soil and crop management practices. Figure 1 addresses three (combinations of) practices for which the scientific evidence was particularly clear: continuous living cover, organic amendments and reduced or no-till systems.

Maintaining a **continuous living cover** on the soil in space and time is the most effective way to foster soil structure. Examples are the adoption over cover crops in arable rotations or an inter-row cover in vineyards, etc. A ‘continuous living cover’ results in abundant and active soil life and more carbon in the soil, both of which are beneficial in the formation of a ‘healthy’ soil structure. Such a healthy soil structure is typically better at infiltrating and retaining water. Agricultural management practices cannot be isolated. They come with synergies and trade-offs for other properties and processes in agro-ecosystems. A continuous living cover results in a healthier soil structure, but also results in increased loss of water through evapotranspiration and reduced groundwater recharge. This potential trade-off might not matter so much in temperate regions, but could be problematic in dry climates. Synergistic benefits of 'continuous living cover' are a reduction of nitrate leaching to groundwater and a reduction of greenhouse gas emissions, except for leguminous cover crops.

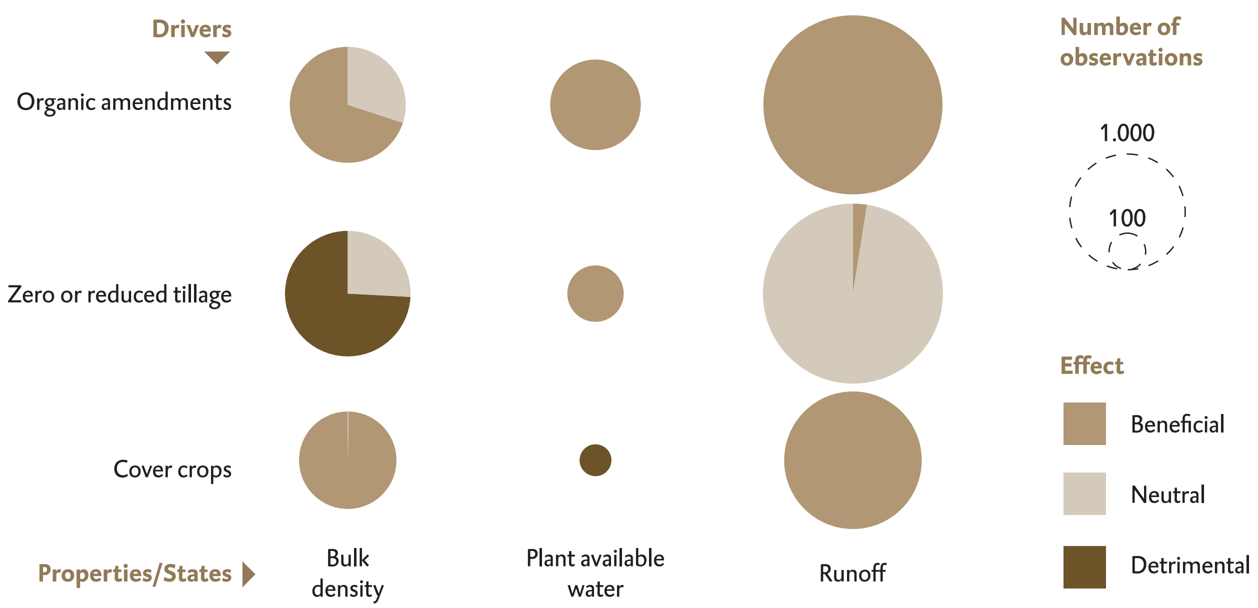
Scientific research on **organic amendments** for agricultural land has focused extensively on the effects of biochar, even though this technique has not (yet) been widely adopted in the agricultural sector. Biochar has a positive effect on soil hydrological functioning. Only a few meta-analyses have focused specifically on the effects of organic soil amendments or residue retention and mulching on soil properties relevant for water regulation functions. Instead, these practices are often included in meta-analyses on conservation agriculture or tillage systems. In these studies, the effects of the treatments are combined. Nevertheless, from the available studies, it is clear that the addition of organic amendments improves soil structure and plant available water and reduces runoff and erosion.

The evidence on the effects of **reduced or no-tillage** shows mixed results, with adverse effects on bulk density, despite improvements in soil structure and available water. Both positive and negative effects on runoff have been reported. In addition, there are significant trade-offs such as increased weed pressure and herbicide use and greater greenhouse gas emissions. Hydraulic conductivity is a measure for the speed with which water can move through a volume of soil, or say, infiltrate. In a detailed analysis of a database containing hydraulic conductivity measurements, we found that the effect of tillage on the hydraulic conductivity was positive, although this depends on the timescale of the analysis. The data also showed that infiltration can be increased by avoiding soil compaction.

Although significant trends are visible in the literature, it is still sometimes difficult to differentiate among pedo-climatic regions and other context-specific factors. Many meta-analyses perform little context-specific analyses, so the information is lacking in the final publication. In addition, there is even often a lack of information in the original studies to extract the necessary meta-data. It is therefore important for studies on agro-ecosystems from all disciplines to agree on standards concerning the required meta-data reported in peer-reviewed studies.

The full CLIMASOMA report summarizes the statistical relationships found between all the selected practices and target variables related to soil hydrological functioning in the selected meta-analyses (chapter 3) -LINK HERE-. There are several significant "knowledge gaps". Although several meta-analyses have focused on the effects of irrigation management or organic amendments on water use efficiency, almost nothing has been published

Figure 1: Scientific evidence for three (combinations of) practices



about the effects of soil management on root growth and water supply to crops, something which is critical for adaptation to future climates with more frequent and severe summer droughts. Some management practices have been less often the subject of field experiments including, for example, deep tillage, occasional tillage, and crop rotations.

For policies and recommendations from scientists to have an impact, understanding farmers' behavior and the socio-economic and policy barriers and drivers experienced and perceived by farmers is imperative. It is therefore important to not only provide context-specific information on the biophysical aspects of a practice, but also on perspectives of different types of farmers. Those challenges and proposed solutions are not addressed here, but in a separate policy brief.

Sarah Garré
sarah.garre@ilvo.vlaanderen.be

POLICY RECOMMENDATIONS AND IMPLICATIONS OF THE RESEARCH

Incentivize the implementation of a year-round soil cover. In temperate climates, the use of cover crops, inter-row crops, etc are recommended, since they actively contribute to soil structure and soil organic matter. In dry climates, this could be challenging due to the additional water use by these crops. In those cases, soil cover with mulch etc is recommended, although the access to organic material often remains a challenge.

Make sure organic matter from agricultural activities stays or returns as much as possible to the field and **encourage addition of organic amendments**. At many farms, the availability of organic material is not given. Local collaborations between farms are to be encouraged, both to increase the availability of organic amendments, as to create opportunities for social learning between farmer.

Reward a reduction of traffic on agricultural land rather that focus only on a reduction of tillage. It is trafficking fields which creates and exacerbates soil compaction, which reduces the potential of a soil to receive and store water. The compaction level for maximum farmer revenue decreases if either producer prices are higher, harvesting costs savings from larger machinery are smaller, or if farmers are charged for (part of the) environmental costs of soil compaction.