DIVERSify Factsheet no. 8

RESILIENCE AND ECOSYSTEM SERVICES

Root overyielding and potential soil carbon benefits of plant teams

ABSTRACT

Plants allocate a major part of their captured carbon to the soil in the form of root production and organic compounds being released by these roots. Some of it stays in the ground as part of the soil organic matter, consisting of living and degraded biological material. Soil organic matter contributes to soil productivity in different ways. Increasing the amount of carbon in the soil is also important to promote soil health and sequester carbon for the purpose of climate change mitigation. Field and crop management techniques that increase carbon inputs should be considered as an important part of long-term farm planning.

Species rich grasslands and intercrops are often found to be more productive in terms of green biomass and grain yield. Furthermore, **increased root volume** is a possibility that ultimately can lead to **increases in the level of soil organic carbon**. Such 'overyielding' effects have the potential of being a straightforward method to boost root production and carbon inputs to the soil.

Below, we present examples demonstrating substantially higher root production in **faba bean and oat**, and **lupin and barley** intercrops when compared to any of the crops grown in monoculture. Finally, we argue that agricultural plant teams should be considered by farmers planning to improve soil health. Recognition within future CAP eco-schemes and targeted carbon removal certification schemes will enable this.

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CONTEXT

When plants capture carbon from the air during photosynthesis, a large proportion ends up below-ground. **Carbon is a primary component of root tissue**, and yearly root production by common cereal crops can amount to 2.5 t/ha, varying significantly with species, weather, soil type and management[1]. A proportion of root carbon is metabolised, degraded and lost to the atmosphere while some of it is stored and remains as part of the **soil organic matter**. On average, plant roots contribute twice the amount of soil organic carbon compared to the shoots[2]. In addition, in their lifetime, plants release up to **50% of their assimilated carbon to the soil as organic compounds**[3].

Fig. 1 We need to look below-ground too to further understand the benefits of plant teams

Carbon input to the soil promotes **soil health** as well as **carbon sequestration**. Field and crop management techniques that increase carbon inputs should therefore be considered as an important part of long-term farm management planning. Recently, studies have demonstrated co-cultivation of crop species as a way to boost root production and carbon inputs to the soil.

BELOW GROUND PRODUCTIVITY

Plant teams are generally **more productive than expected** when compared with plant stands with fewer species; this is known as **overyielding**. In plant teams such as species rich grasslands and intercrops, this is often acknowledged as more biomass or higher grain yields (to read more also see DIVERSify Factsheet no. 4 and no. 5). However, recent research has also shown that overyielding by plant teams can also occur **below-ground**, contributing to **higher root production, deposition of soil organic carbon and a better exploitation of soil resources**.

One of the main mechanisms for overyielding is attributed to **complementary root growth**, contributing to **higher uptake of water and nutrients**, particularly under growth conditions where those resources are limiting[4]. For example, growing deep-rooted and shallow-rooted crops together has been shown to allow plant **access to distinct volumes of soil**[5]. We explore this concept in relation to interactions with weed communities in DIVERSify Facsheet no. 3, and drought tolerance in no. 6.

Co-cultivation of crop species with different timing in resource requirements, e.g., through **relay intercropping**, can also help optimise plant root production and **reduce competition for limiting soil resources**.

EXAMPLES OF ROOT OVERYIELDING

In the DIVERSify project, several experiments were run to study the effects of intercropping on root production and nutrient uptake. In one experiment in Denmark, intercropped **faba bean** and **oat** (sown in 50:50 ratio) showed similar **overyielding of root (38%) and shoot (33%) mass** (Fig. 2). The root mass of faba bean was higher than that of oat, while the root mass of the two combined was even higher.

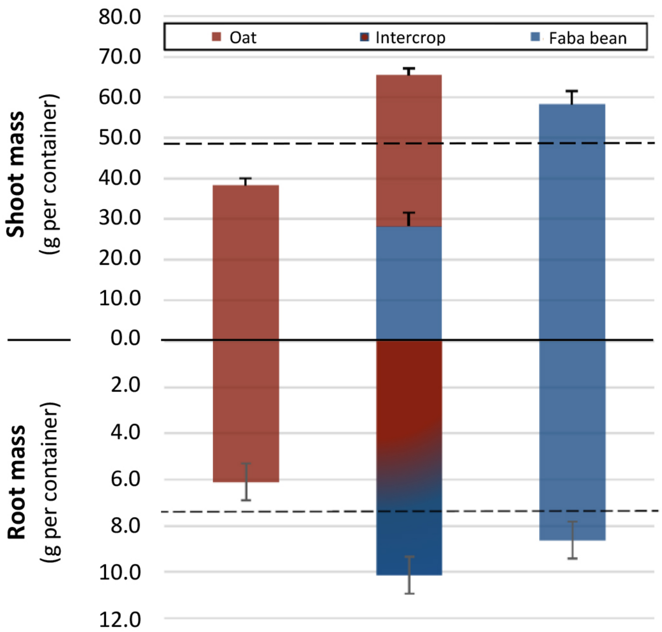

Fig. 2 Root and shoot overyielding in a faba bean and oat intercrop (50%:50%). Broken lines mark the monocrop averages

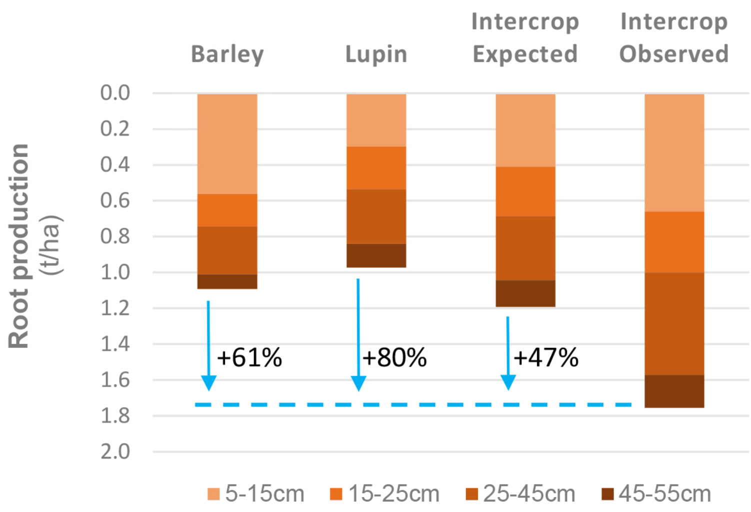

Fig. 3 Root overyielding in a lupin and barley intercrop (100%:20%) in different soil layers

Furthermore, intercropped **lupin** and **barley** (100%: 20%) showed **root mass overyielding of 47%** compared to the expected average (Fig. 3). This translated to an increase in deposited root tissue carbon of approximately 0.25 tons per hectare in the upper 0.5m of the soil alone. Stratified sampling indicated that overyielding occurred in all soil layers.

CONCLUSION

Soil carbon sequestration is receiving attention as a key measure in climate mitigation and as a cornerstone of regenerative farming. Even small increases in root production per area could have a large impact, given the areas of farmland under cultivation. Plant teams appear to offer great potential for storing more carbon on European farmlands and thus provide a means to quickly scale up the EU's ambition for obtaining climate neutrality by 2050. We recommend that farmers and policy makers consider intercropping within the framework of future CAP eco-schemes and targeted carbon removal certification schemes.

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FURTHER INFO

> Read on to discover more about the wider benefits of plant teams and how these could be recognised within agricultural policy:
> DIVERSify Factsheet no. 9 - DIVERSify Factsheet no. 10

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