How do Living Mulches Impact Soils and the Environment?

Learnings from our research at Denby Hall Farm

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Farming Innovation Programme and Innovate UK

To better understand the wider benefits and drawbacks of diversified cropping systems, researchers at ORC have been assessing the impact of different perennial legume understories, or living mulches, on biodiversity, carbon sequestration and soil health.

- Biodiversity metrics were higher in living mulch systems, which were particularly beneficial to pollinators and soil fauna
- Establishing living mulches also led to reduced net carbon balances compared to controls
- We found that soils underlying many of the living mulch species mixtures had higher organic matter and better structure than those without mulches



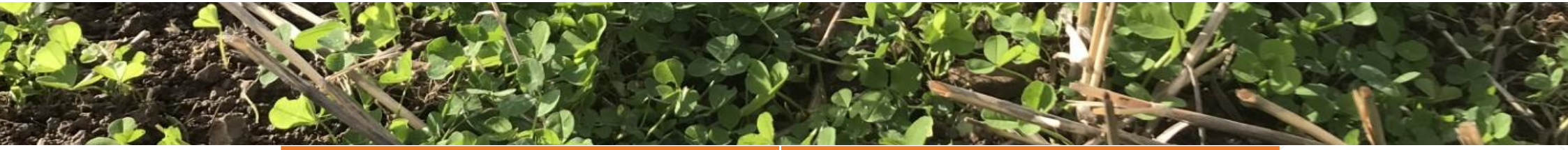




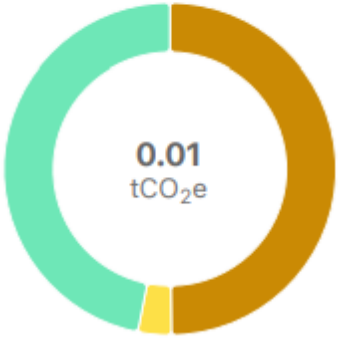
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Biodiversity and carbon sequestration is higher in Living Mulch systems

Using Sandy from Trinity Agtech, we analysed results from all the mulch treatments and found that associated emissions were higher, and sequestration was lower in strips without living mulches. Biodiversity scores for pollinators were much higher in the mulch treatment strips.



NET CARBON BALANCE



Scope 1 | Scope 3 (off-farm) | Sequestration

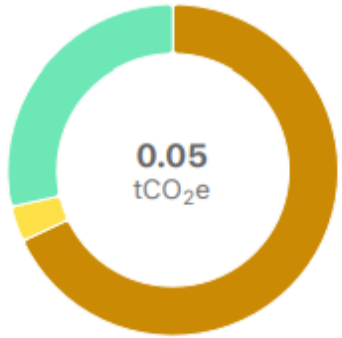
Living Mulch Strips

Farmland wildlife	2.8 / 5
Conservation species	2.6 / 5
Natural enemies	4.5 / 5
Pollinators	3.1 / 5
Soil biodiversity	4.3 / 5

Headland Strips

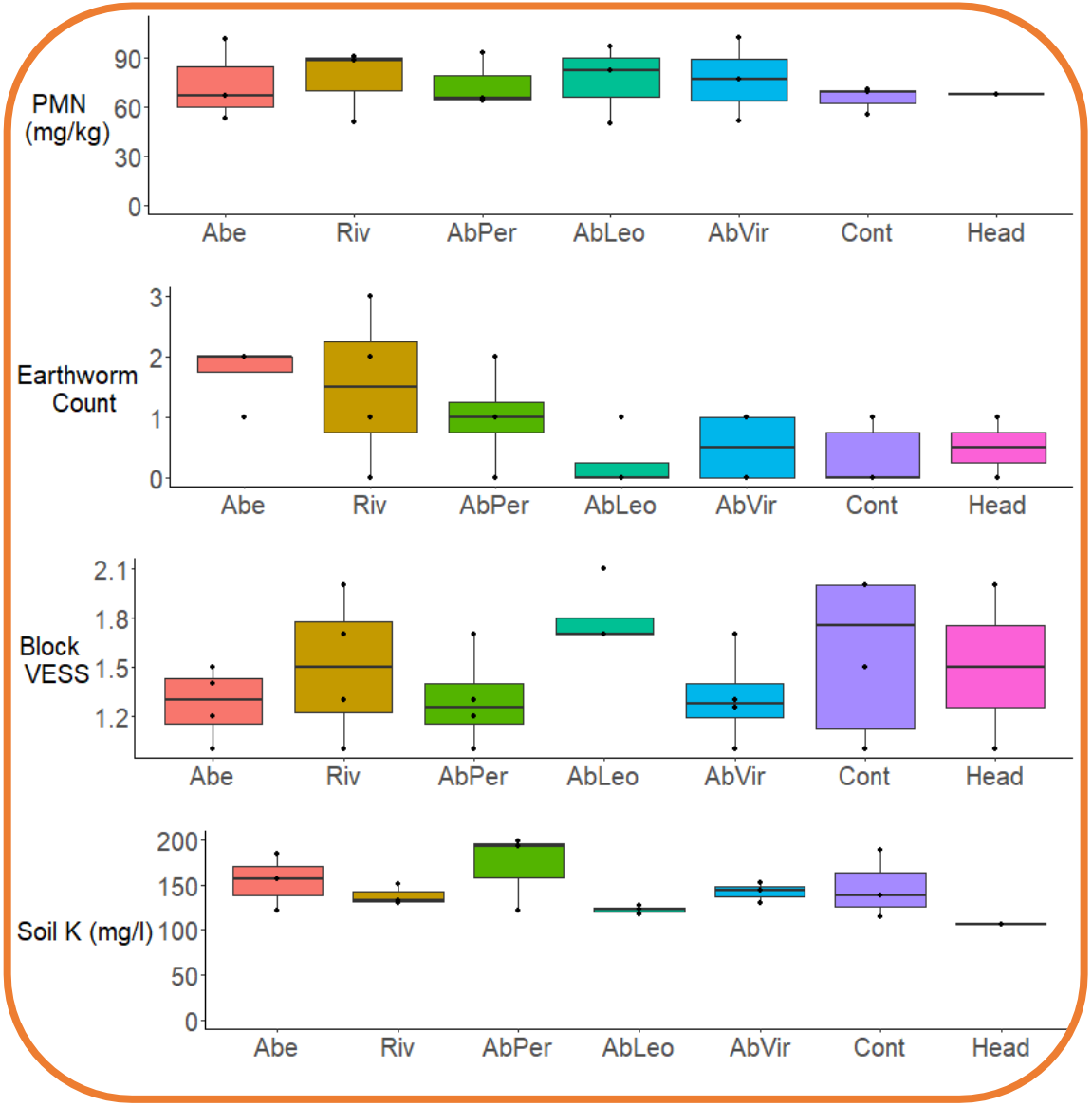
Farmland wildlife	2.4 / 5
Conservation species	2.8 / 5
Natural enemies	4.4 / 5
Pollinators	1.9 / 5
Soil biodiversity	4.1 / 5

NET CARBON BALANCE



Scope 1 | Scope 3 (off-farm) | Sequestration





Some early indications of better soil health were identified underlying selected living mulch species

- Microbial activity assessed using potentially mineralizable nitrogen (PMN) did not significantly differ between the treatment strips
- There were higher earthworm numbers in single-species living mulch strips (Aberace and Rivendel) than in those without mulches
- Soil structure (determined via VESS score) was generally better in strips containing living mulches
- Plant available soil potassium (K) was slightly higher in living mulch strips compared to control and headlands

There is clear evidence that establishing living mulches can potentially improve soil health and wider environmental outcomes

Establishment is key to success of Living Mulches

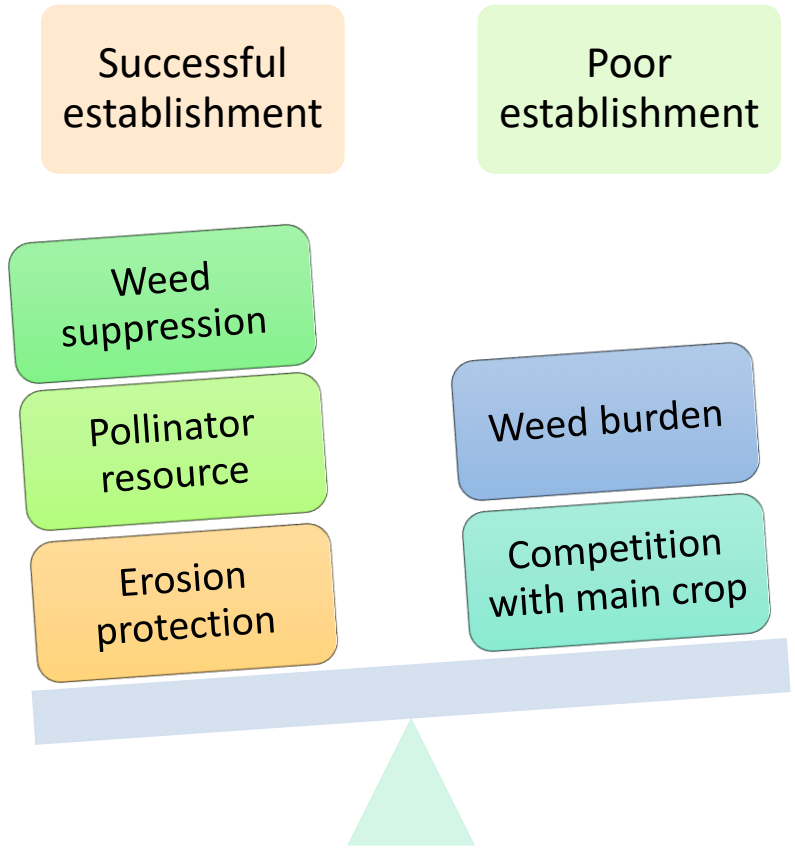
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Finding the balance between a healthy thriving mulch and crop-compromising competition can be difficult for growers, particularly in organic systems where management options are limited. In our work with Denby Hall Farm, ORC researchers have found that the decisions made at establishment – including timing and kit used - are key to giving both cash crop and mulches the very best start in the field for a successful season.





Living Mulches FIP

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Field 1: Allow mulch to establish prior to main crop

Mulch establishment	Year 1 -Crop establishment Winter wheat	Weed Management	Crop Harvest	Year 2- Crop establishment Winter oat
August 2024	October 2024	Spring 2025	July 2025	October 2025
• Mulch species combi drilled into tine cultivated seed bed following mown and disced fertility boosting cover crop. Seed rate 8 kg/ha. Flat rolled.	• Wheat drilled with a direct disc drill (Sky drill), 24th of Oct. • 150% of typical seed rate	• Spring tine harrowed • Flail mown => Significant weed pressure.	• Low crop yield. Direct drilling not successful in mulch or control strips.	



Strip till drill (Claydon). 150% typical seed rate.

Lessons learned

- August mulch establishment timing combined with direct drilling resulted in a high weed burden.
- Direct drilling was not successful in the mulch or control strips.
- Establishing the crop with a strip till drill in year 2 was more successful.
- Year 2 has a manageable understory of mulch alongside a healthy crop – impacts for year 2 on yield and weed suppression is yet to be seen!

Field 2: Establish crop first to limit mulch-crop competition in year 1

Year 1 -Crop establishment Winter wheat	Mulch establishment	Crop Harvest	Year 2- Crop establishment Winter oat
October 2024	Spring 2025	July 2025	October 2025
• Wheat drilled with a combi drill, 15th of Oct. • 100% typical seed rate.	• Crop under sown with mulch using a spring tine weeder with seed box. Seed rate 8 kg/ha.	• Full crop yield	• Strip till drill (Claydon) 150% typical seed rate.

Mulch establishment year — *'True' Living Mulch year*

- Autumn crop undersown with living mulch species in spring allowed full crop harvest in year 1.
- Mulch in year 1 can be patchy, establishment can be difficult in a dry spring.
- Mulch cover variable in spring of Y2 in spring – the impact on year 2 crop harvest is yet to be seen!



Next steps

Alex and Hannah's reflections on crop management of living mulches

- *"Next, we might try to establish the cereals and the mulch together at a time when it's not too late for the clover to germinate and grow, such as mid-September. There is always the potential to top-up in spring in case of low mulch establishment!"*
- *"Instead of planting after harvest, the mulch could be established after an easily mechanically terminatable cover crop with a lot of biomass which can suppress weeds over winter, slightly ahead of the cereal."*
- *"Our farm wasn't suited to direct drilling. The strip till drill is definitely our choice to put your cereal into a mulch."*
- *"It would be good to know which mulch species or mixes are most shade or drought tolerant for spring undersowing to maximise the chances for good clover establishment in year 1."*

Living Mulches: which species to choose?

Learnings from our research at Denby Hall Farm

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Farming Innovation Programme and Innovate UK. We thank Cotswold Seeds for seed provision.

Working with Denby Hall Farm, we trialed five potential companion crops to work out which was most suitable for use as a living mulch in an organic, minimum-tillage farming system alongside cereal crops. The living mulches were established in August and the crop in October. We found:

- No significant differences found between treatments this season, would be interesting to measure differences in year 2. Species composition may not be a critical decision when designing living mulch systems.
- Successful establishment was key to crop and mulch performance in all species considered.
- Persian clover generated the most biomass and senesced in time for harvest.

AberAce White Clover	Rivendel White Clover	Virgo Pajberg Black Medic only	Leo Birds Foot Trefoil only	Persian Clover
£17.50 /kg	£25.00 /kg	£15.10 /kg	£18.90 /kg	£10.90 /kg

Seed cost indication for March 2025

AberAce White Clover *Trifolium Repens*

"Slow growing, small clover. Took a long time to establish"



Seed rate: 8kg/ha - £17.50/kg

Plant architecture/growing habits – Perennial species with small leaves and a creeping growth habit. It remains short and forms a low understory layer beneath the cereal crop. Its rooting depth is similar to that of cereals, which may increase competition for nutrients and water and potentially affects crop performance.

Spring Cover and Harvest Biomass – Relatively good cover in establishment year and persists well. Fresh biomass production was not significantly different from other mixes (438 ± 90 g/ m²).

Rivendel White Clover *Trifolium Repens*

"Similar to AberAce, small and slow growing clover. It also took a long time to establish"



Seed rates: 8kg/ha - £25.00/kg

Plant architecture/growing habits: Small leaved perennial clover, remains short and forms a low understory layer beneath the cereal crop. As with AberAce, rooting depth is similar to that of cereals which may lead to competition with the crop.

Spring Cover and Harvest Biomass - Medium cover with some difficulty to establish observed in the field. It appears less competitive than AberAce and may be of interest to reduce competition with the main crop especially in the 2nd year of LM system. Biomass no different from other mixes (436 ± 90 g/ m²).

AberAce White Clover + Virgo Pajberg Black Medic *Medicago Lupulina*

" Both Black Medic and Birds' Foot Trefoil should limit competition with the wheat and enhance farmland wildlife and soil biodiversity but both could grow too large and interfere with harvest if the plant become tall and rambly in its' second year of growth."

Seed rates - Aberace 4.2kg/ha – £17.50/kg, Virgo Pajberg 3.2 kg/ha £15.10/kg

Plant architecture/growing habits – Legume with a deep tap root and low growth habit. It has a short life cycle: dying off after flowering and self-seeding. It can complement white clover in a mix and limit competition with the main crop.

Spring Cover and Biomass learnings – Variable ground cover due to difficult establishment of the black medic combined with a lower rate of AberAce. Biomass at harvest did not significantly differ from other mixes. The slightly higher results suggests that when successfully stablished, Black Medic has the potential to produce relatively high biomass (483 ± 90 g/ m²).

AberAce White Clover + Leo Birds' Foot Trefoil *Lotus corniculatus*



Seed rates - Aberace 4.2kg/ha - £17.50/kg Leo 3.2kg/ha - £18.90/kg

Plant architecture/growing habits – Perennial legume with a long tap root which can help reduce competition with the main crop for nutrient and water. It has an upright to prostrate growth habit due to its numerous stems.

Spring Cover and Biomass Learnings - Similarly to the AberAce/Black Medic mixture, cover in spring was limited due to challenging establishment of the trefoil and the lower seed rate of white clover. Biomass production was not significantly different from other mixes nor showed any specific trend (443 ± 90 g/ m²).

AberAce White Clover + Persian Clover

Trifolium respinatum

"Biggest surprise of them all! The Persian clover was intended to be an N-fixing 'nurse' clover to the smaller Aberace and die back over winter to leave the Aberace to slowly grow out in the base. However, it didn't die back and became a high-volume companion crop to the wheat during the growing season. Thankfully the Persian clover senesced completely before harvest being an annual plant and didn't interfere with harvest at all, and provided lots of seed for volunteers to grow alongside the second year's arable crop with the Aberace micro clover now well established"

Seed rates - Aberace 8kg/ha £17.50/kg Persian 2kg/ha - £10.90/kg

Plant architecture/growing habits - Persian clover is an annual legume with rapid erected growth. It is tall but flowers early, self seeds and senesces before harvest. It can help weed suppression in spring. The white clover of the mix can take over once established.

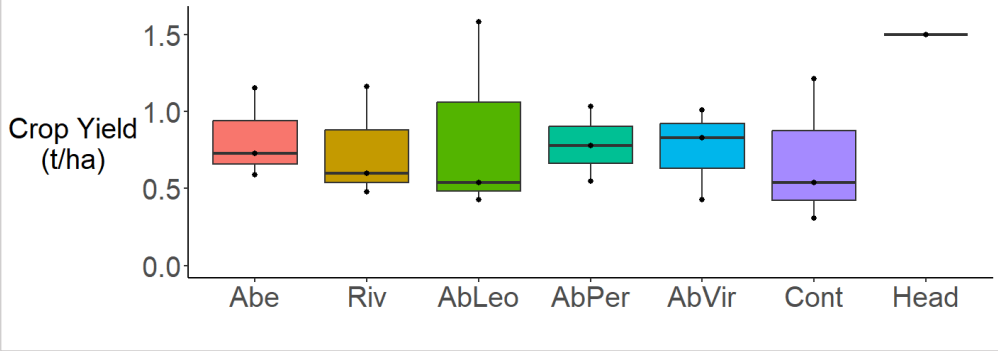
Spring Cover and Biomass learnings – The mix achieved relatively good ground cover due to AberAce seed rate and taller growth of the Persian clover. Cover was variable due to the uneven distribution of the Persian clover and fresh biomass at harvest did not significantly differ with the other mixes, probably due to the Persian clover early senescence (398 ± 90 g/ m²).





Persian clover

No significant difference between mulch mixes on wheat yield



We found no significant difference in yield between the mulch treatment strips, including the Controls (ANOVA, p = 0.75, F value = 0.55). Yields were up to 70% lower in mulch strips than Headlands (30cm depth tillage before drilling). This likely reflects the direct drill technique used for the wheat (see establishment fact sheet) and increased crop/mulch competition for nutrients and water.