Feature

Durability and resilience: can we fix our soils?

If you dare, cast your memory back to the spring of this year 2020. Unfortunately, it was the 'perfect storm' in terms of soil management and seedbed preparation. Following the extremely wet winter there were few chances to plough in the right conditions, this was followed by rapidly drying soils in spring, providing narrow windows to get secondary cultivations completed. Adding 'insult to injury' the absence of any rain after drilling left seed sitting in some very dry, poor seedbeds, resulting in delayed and patchy emergence across fields and where germinated, seedlings struggling to establish. It was one of the poorest seasons for crop establishment for many years. All of this, before the first aphid landed!

In this article we look at what we can do to improve the durability of our soils to these weather patterns and their resilience to recovering after such events. Unfortunately, the climate scientists predict we will get more wet winters and dry springs going forward and worryingly the spring of 2020 could become part of the 'new normal' to use a current phrase. So, whilst we cannot change the weather, what other practices are there to consider that may help us to manage our soils, particularly from the perspective of managing soil structure and preparing seedbeds ahead of drilling.

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Managing Soil Structure

Of course, it is important to preface any discussion about soil management by remembering there is no single set of on-farm management practices that can put soils in good health. Good soil management requires a flexible approach that is likely to vary from field to field, and season to season.

Addition of organic material – a multi-functional tillage tool

The addition of organic material is arguably one of the most significant ways of improving the durability and resilience of our soils. Information from three years of the Beet Yield Challenge (BYC) has shown a clear trend that where organic material has been applied, straw chopped and incorporated or where cover crops are grown, crop performance, in terms of plant population, yield and yield as a percentage of potential is increased.

Consequently, much of BBRO's work with BYC growers has been to consider introducing more organic materials into their rotation. Usage has increased, and in 2020 >60% of the crops received organic materials; 40% grew a cover crop and 30% used both organic materials and cover crops. Over the three years we have seen yields (as a percentage of their potential) increase by 10% and whilst this improvement is due to a whole range of factors, two of the three years had periods of significant drought. We can conclude that some of this improvement is therefore due to better soil durability and resilience.

In lighter soils, the ability to retain moisture is key to improving seed germination and early establishment. It has been estimated that raising the organic matter by 1% is equivalent to applying an additional 100,000 litres/ac of available water (in old irrigation currency, an acre inch is 122,000 litres)

In soils with clay or clay-loam textures, the properties of the clay minerals present mean they swell as they absorb moisture and shrink as the moisture is released. These wetting and drying processes are key to the formation of pore and aggregates and are enhanced where the soils receive regular inputs of organic matter. Good soil structure increases the duration of the cultivation window on these soils. It also minimises tillage costs – in terms of tractor hours, number of passes, and size of tractor and implements required.

The photograph above shows the impact of how organic matter can assist a clay-based soil. This was taken at BBRO/ADAS organic amendment trial at Terrington in 2019 on a silty clay loam. The plant on the left was typical of those in plots which had received organic manures and the plant on right, of plots receiving no organic manure. Compare the difference both in plant size and vigour but also the soil structure beneath the two plants. The organic manure treated soil has a much better mixture of well-rounded soil aggregate, good root penetration and structure compared to the untreated soil which has larger aggregates with horizontal layering and fewer pores and cracks.

As a result, plant populations were raised by between 10% and 20% by organic material additions, Farmyard Manure (FYM) and green compost giving the largest increases. Yield increases of up to 11% were recorded in the FYM treated plots.

Use of cover crops as a soil engineering tool

Whilst we have good information on how the addition of organic manures can help improve soil structure, what about cover crops? Whilst cover crops have potentially many useful functions, if we just focus on their effect on soil structure, how useful are they as a soil engineering tool?

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Can well rooted cover crops such as Phacelia be effective 'biological tillage tools'?

Dr Jake Richards recently completed his BBRO-sponsored PhD, looking at cover crops. Working across a range of soil types, Jake was able to measure several impacts but his work on a heavy clay in Suffolk is of particular interest. Using a range of cover crop species, conditions favoured the growth of forage rye (Secale Cereale) and black oat (Avena strigosa) compared to tillage radish (Raphanus sativus) and Egyptian clover (Trifolium alexandrium).

As a result of their root characteristics, soil aggregation after the cereal cover crops had a larger proportion of small and medium aggregates in comparison to bare soil and tillage radish (Fig.1). It is possible that with an increase of small aggregates there is likely to be better seed-soil contact which has been linked to better sugar beet establishment.

Alongside Jake's PhD work, BBRO on-farm monitoring of commercial cover crops has also found some consistent effects of cover crops on the soil. This is typified by measurements made at the BBRO Demonstration Farm at the Rougham Estate:

- Drying of soil
- Lower soil resistance
- Higher earthworm numbers
- Good rooting depth to influence different parts of the soil profile (varies with species)
- Better aggregates, size distribution
- Measurable nitrogen contribution by legumes
- Better VESS score
- Higher microbial activity (indicated by microbial CO_2-burst test)

Our view is that well rooted cover crops will have a positive impact on soil structure ahead of beet and measurements have shown how this can assist with seedbed preparation and better plant populations. However, we should be mindful that a cover crop will remove moisture from the soil, which in a wet spring is a positive, but in a very dry spring may possibly compound issues. It is also important not to view cover crops as a quick fix. Compared to the addition of organic materials, the impact is slower and may require several cover crops in the rotation before impacts on soil structure are seen. Our experience is also that where growers combine the use of organic material and cover crops in their rotation there is an additive effect.

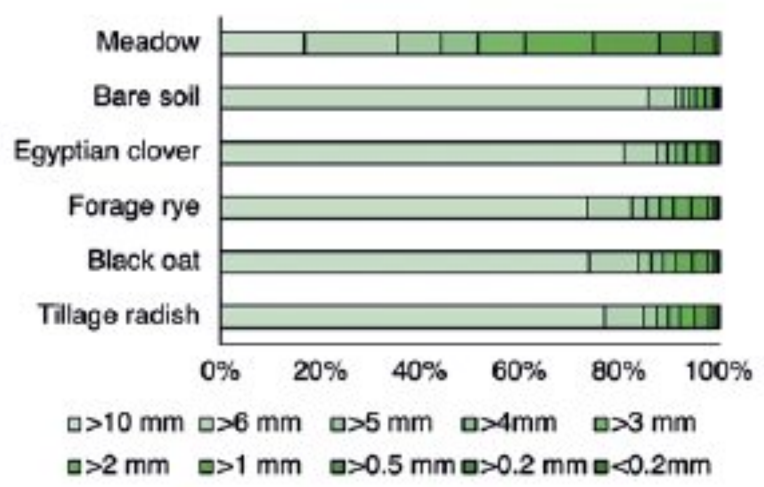

Fig.1. Aggregate size distribution of soil profile at cover crop destruction

Fig. 2. Stubble (top left) and cover crop (bottom left) getting to work on the soil and creating drier and better aggregate size distribution (note the earthworm)

Will adoption of reduced tillage make our soils more durable and resilient?

It is relatively well demonstrated that tillage and compaction can result in:

- Disrupting the connectivity of pores and water films in the soil, changing the air/water balance and higher risk of soil damage and compaction
- Reduced soil biological activity. Earthworm numbers have been shown to be higher under reduced tillage.
- Can increase erosion and loss of nutrients
- Higher organic turn-over and loss, over time

So, from our theoretical understanding of soil structure, the expectation is that reduced tillage will help. However, from a practical and crop performance perspective, this is not clear cut at all and indeed, trials looking at different reduced tillage regimes often produce conflicting results.

The broad concensus from previously published scientific work is that reduced tillage on sugar beet had been linked to the following, although not in all cases:

- More variable plant populations
- Increased soil resistance and bulk density (poor root penetration)
- Reduced availability of pore space (less water and air availability) especially at depth
- Reduced yields

Recent BBRO cultivation trials (long-term tillage STAR project with NIAB in Suffolk* and BBRO Demonstration Farms) both with sugar beet, highlighted the challenges in establishing clear trends in cultivation. With site and seasonal interactions, the results are difficult to interpret and establishment values do not always explain the variance in yield perhaps highlighting the influence of soil characteristics deeper in the profile (particularly in dry years).

BBRO trials exploring different cultivation strategies

	Primary Cultivation	Secondary cultivation	Establishment (%)	Sugar yield (t/ha)
Rougham 2018	Strip till	N/A	65.3 +/- 12.1	14.4
	Deep tine min till	Power harrow	72.6 +/- 2.6	17.7
	Plough	Power harrow	60.9 +/- 7.8	18.7
Morley 2018	Plough	1 x combination harrow	68.3 +/- 7.7	20.0
	Plough	2 x combination harrow	75.9 +/- 2.7	21.4
	Plough	3 x combination harrow	71.1 +/- 4.0	21.2
Morley 2019	Strip till	N/A	78.3 +/- 1.5	11.4
	Shallow tine min till	Spring tine	80.0 +/- 4.6	12.1
	Deep tine min till	Spring tine	85.8 +/- 1.4	14.2

Fig. 3b. STAR project

Fig. 3b. BBRO cultivation trials

A view that ploughing and non-inversion/reduced tillage regimes all have a place in sugar beet rotations but are not mutually exclusive to each other, seems sensible. However, what is clear is that sugar beet require an element of deep loosening, especially to assist with deeper root activity and alleviation of structural issues to which beet is very sensitive. It is perhaps advisable to take a perspective that ploughing at some point in the rotation, possibly ahead of sugar beet on certain soil types is required. Of course, how we integrate approaches of using manures and cover crops in with different cultivation strategies is interesting and requires an element of long term commitment and monitoring to identify what is right for each parcel of land on a farm. One of the most common comments of our Demo Farm growers who are doing this, is that the benefits take time to be realised.

In this article, we set out to answer the question can we make our soils more durable to the extremes of our weather and more resilience in their response to these extremes?

Hopefully, we have been able to show there are approaches and practices which have been shown to deliver benefits. However, when improving our soils, there is no such thing as a 'quick fix'. Growers who have implemented changes, who are flexible in their approach to soil management and committed to improvement can evidence the benefits.

Sugar beet will be susceptible to the predicted changing weather patterns, not just from the perspective of soil moisture extremes, but also from changing virus, pest and disease pressures. Ensuring soils are able to support rapid crop emergence and canopy establishment and sustaining growth through to harvest is key. Do not lose sight of the vital role that soil plays in this.

Further information

*For more information regarding the STAR project please go to: https://www.niab.com/research/agronomy-and-farming-systems/farming-systems/sustainability-trial-arable-rotations-star

For more information on Soils Matters please visit https://ahdb.org.uk/GREATsoils