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Soil health – Measure, Manage and Monetise

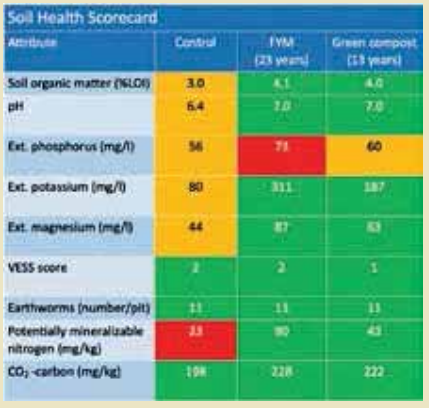
The measurement and management of soil health has been a key feature in recent editions of *Sugar Beet Review,* and this is linked to a strong conviction that improvements in soil health can drive higher sugar beet yields. With the release of the new soil health scorecard, we now have a tool that allows us to benchmark soil health and to compare between soil management practices. However, we are frequently asked to quantify and monetise the impact of improved soil health on commercial crop performance. This is a challenge when working with whole or part field soil management practices and especially without the aid of yield mapping technology on beet harvesters to measure impacts.

However, in this article we revisit some data from the Beet Yield Challenge (BYC), using a set of soil measurements which we have used to create a soil health scorecard for each field. We then look at the soil health scores in relation to the delivered yield and potential yield.

Soils under the soil health scorecard magnifier

The soil health scorecard has been developed as part of the AHDB led 5-year Soil Biology and Soil Health Partnership, with BBRO being a key partner and a co-funder. It forms an essential part of the toolkit which allows us to benchmark soil health and involves measuring a suite of physical, chemical, and biological soil properties. It uses a red-amber-green (RAG) scoring approach with each value carefully benchmarked and 'road tested' across a range of soils, rotations, and agro-climatic areas. It has also been used to assess and compare soil health across of a range of soil management practices in some long-term trials. Figure 1 summarises the key aspects; more information on the scorecard and the different RAG categories can be found on the BBRO website: https://www.bbro.co.uk/on-farm/soil-matters/.

As the scorecard is new, there are relatively few studies where soil health scores have been compared across different commercial sugar beet crop yields. The BYC initiative provides a unique opportunity to retrospectively link soil health to sugar beet yields.

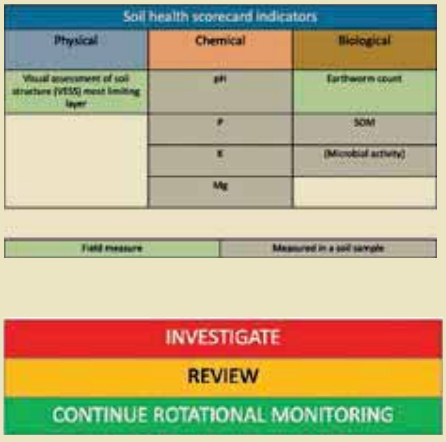


Soil Health Scorecard

Attribute	Control	FYM (23 years)	Green compost (13 years)
Soil organic matter (%LOI)	3.0	4.1	4.0
pH	6.4	7.0	7.0
Ext. phosphorus (mg/l)	56	71	60
Ext. potassium (mg/l)	80	311	187
Ext. magnesium (mg/l)	44	87	63
VESS score	2	2	1
Earthworms (number/pit)	11	11	11
Potentially mineralizable nitrogen (mg/kg)	23	90	43
CO_2 -carbon (mg/kg)	198	228	222

Source AHDB 2021

Fig.1. The soil health scorecard



In 2019, BBRO soil sampled and assessed each of the 30 BYC fields. These assessments covered all the elements of the soil health scorecard providing a unique opportunity to calculate a soil health score for each field. The tests included the measurement of microbial activity using

the CO_2 burst test (often referred to as the 'Solvita test'). This is a unique test in which the microbes themselves generate the result as it measures the release of CO_2 following the addition of water to an air-dried soil sample, therefore providing a direct measure of soil biological response.

Interestingly, weather-wise, 2019 had many similarities to the 2022 season, with a very dry spring and a significant summer drought, albeit not as hot as 2022. Again, like 2022, there were some good conditions for crop recovery in the autumn, although there were no beet moth in 2019!

Across the 30 fields in 2019, a total of 240 soil attributes were measured and assigned a red, amber or green rating in line with the soil health score values. Across all the fields, the average proportion of soil attribute scores were 62% as green, 23% as amber and 15% as red.

Figure 2 shows a summary of the relative proportions of each of the eight-attributes recorded. The highest proportion of reds (areas requiring investigation) were VESS (soil structure) earthworms, and the CO_2 test. Soil organic matter (SOM) and pH also had a high proportion of ambers, and earthworm numbers had the highest number of combined reds and ambers.

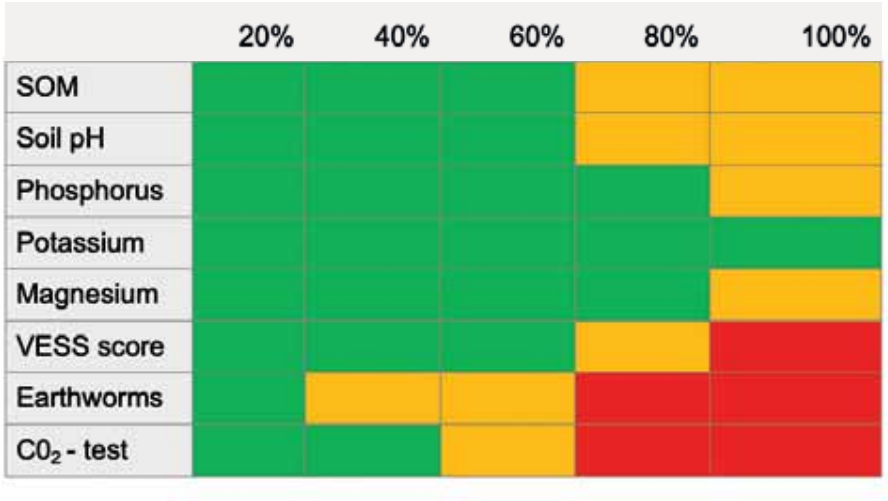


Fig.2. Relative proportions of red-amber-green soil health attribute ratings across the BYC fields

Soil health scorecard and yield performance

The distribution of delivered yields from twenty-nine fields is shown in Figure 3. (Yield in one of the thirty fields was not measured.) These were based on delivered 'flagged field' yields and adjusted for sugar content. It should be noted that the majority (74%) of the crops in the BYC in 2019 were harvested and delivered after the beginning of November. This will explain the higher levels of yields than the national crop yields in 2019. The potential yield was also calculated for each field using the beet yield model. This uses soil type, drilling, harvest date and local weather data to estimate the potential yield.

Figure 4 shows that a larger delivered yield was associated with a higher percentage of green soil scores on the soil health score card for each field. In Figure 5, a higher proportion of green soil scores is also associated with higher proportion of potential yields achieved, compared to the actual delivered yields.

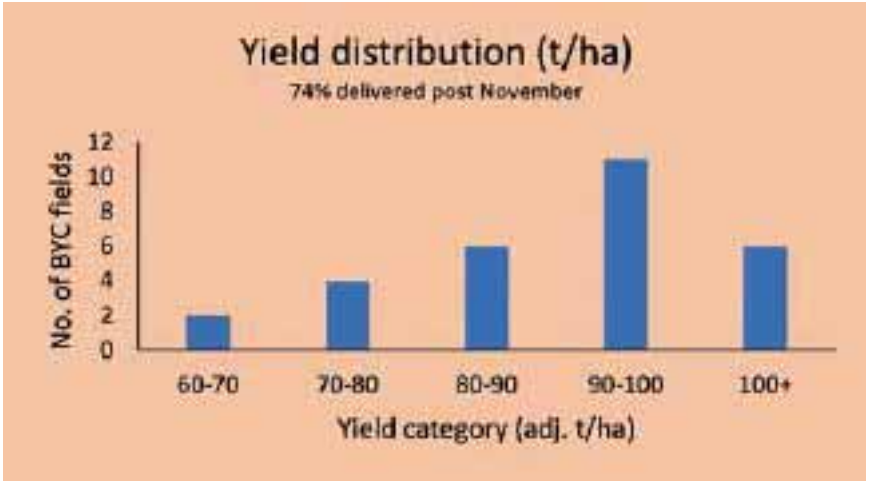


Fig.3. Yield distribution of the BYC crops in 2019

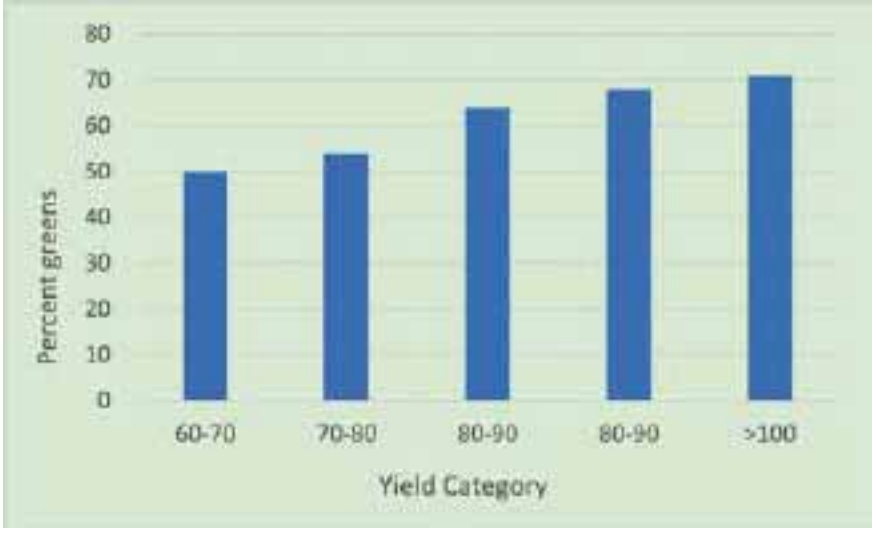


Fig.4. The percentage of green soil ratings in each delivered yield category (adjusted t/ha)

Soil health:
Measure, manage and monetise
Key measures

Soil structure

Microbial activity

Number of earthworms

Soil pH

Key management practices

Organic amendments

Cover crops

Incorporation of straw

Crop performance

Resilience to drought

Good soil health scorecard associated with additional return of circa £650/ha

Improved recovery

This is likely to be due to the impact of foliage diseases such as cercospora on the delivered yields. Wet conditions in late autumn resulted in some moderate cercospora infection in some crops. The model that estimates the potential yield assumes a healthy canopy is retained.

As the potential yield estimates, standardising (to a degree) the impact of soil type, weather, drill and harvest date, it is possible to look at an overall impact of having more green soil attributed ratings. On average, crops scored as having 79% green soil attributed ratings as opposed to 50% greens achieved 18% more of their potential yield, representing an additional 16 t/ha of the delivered yields. Using the 2023 beet price this would represent an extra £650/ha of income/ha.

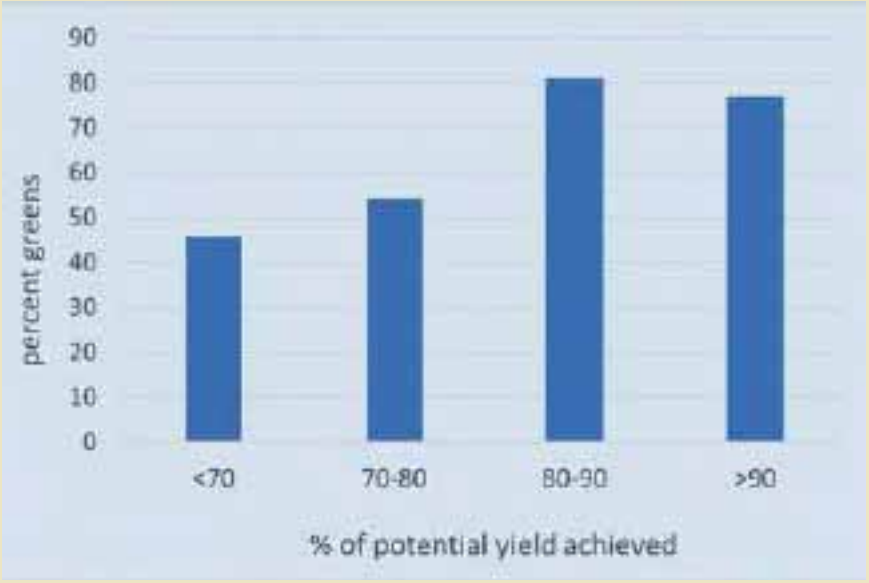


Fig.5. The percentage of green soil ratings in each % of potential yield achieved category (adjusted t/ha)

Relationships with yield are complex!

Whilst this analysis goes someway to validating that a higher soil health score can be linked to better crop performance, we should acknowledge that this is a relatively simple analysis, and we should not ignore that many impacts may be multi-factorial and there will be interactions between factors; especially that of harvest date. This analysis also involves assessment of impact on beet yields in a single year and point in the rotation. It is recognised that, in most cases soil health impacts will require longer time periods to both manifest and be monetised. However, using site specific yield potential is a useful approach as this standardises soil type and weather affects.

As the BYC crops were monitored in detail, and records kept of soil management practices, it allows us to make some observations on those crops in 2019 and provide some key pointers to which management practices were linked to better soil health scorecards and then linked to better yield performance. So, what can we learn?...

As expected, the use of organic amendments (mainly Farm Yard Manure in the 2019 study) and inclusion of cover crops were associated with better soil health scorecards and yield performance. Records in 2019 showed that in most fields where, organic manure had been applied, this had been applied on a regular basis across rotations. Where cover crops were recorded, these had been grown either just once or twice in the rotation.

The analysis has also highlighted the importance of the soil biological function and the link with yield which is becoming clearer. The greater number of red and amber soil attributes in the soils studied were associated with earthworm numbers and the CO_2 test of microbial activity. Targeting these characteristics is one approach to delivering benefits more effectively.

Measurements of crop canopy prior to harvest in 2019 also highlighted how healthier soils, i.e., those with a better soil health scorecard, were associated with improved crop cover. This was due to better new canopy re-growth following the drought (like 2022). This is a key yield component of UK sugar beet yield and as this study reminds us, not only is reliance to stresses such as drought influenced by soil health but so is the recovery.

The records also demonstrated that fields where straw was retained and incorporated, and interestingly those which had a 4-year break or longer between the previous sugar beet crop were also associated with better soil health score cards and yield performance.

There was no clear difference between the yields and the soil health scorecards of crops in ploughed and non-ploughed fields, and whilst a number of fields were amber for pH, there was no clear effect on yield in these fields. A separate study as part of the Soil Biology and Soil Health partnership project assessed microbial function (CO_2-burst test) in relation to pH, finding that microbial activity was reduced below pH values of six and above values of eight, reminding us of the importance of measuring and managing pH levels. Although not a score card attribute, BCN was assessed in each field and found to be present in a higher-than-expected proportion of fields. Do your soils need to be BCN tested?

Check out our key measures and management practices (see previous page):

Can you improve your yield?