Beet Yield Challenge 2018/2019

Introduction

This is the report on the 2018/19 Beet Yield Challenge and is the second year of the BYC project. The BYC is a collaboration across the sugar beet industry and we would like to express our thanks to all the growers for participating and opening their crops up to intense scrutiny in such a challenging year. Thanks, are also due to the numerous people who have helped collect data over the season.

Remember that the BYC is not about who can produce the largest yield; the focus is on comparing the actual yields of crops against an estimated potential yield. This is calculated using a crop growth model. The aim is to monitor a range of crops across the UK beet growing area to understand and learn about the key drivers of yield. Inevitably, this involves a large amount of data and we have attempted to keep the detail to a minimum in this report and highlight the key observations for you.

There were 26 crops in the 2018 BYC which were followed through to harvest. The BYC works best when we can compare across a range of crops grown on different soil types with different drilling and harvest dates as well as different agronomic practices.

Whilst, the 2018 BYC has diverse range of crops, it is worth noting than many were drilled later than usual, and most were left for later harvesting date and therefore limited the range of comparisons. Whilst we're sure you don't need a reminder of the extraordinary weather in 2018, remember it was in stark contrast with the weather in 2017.

We hope you find something of interest

The BYC Steering Team

2018 Yield Performance

Table 1 summarises the yield across the 26 crops. The yield as a percentage of the potential is given as one of four categories:

Less than 60%	60-70%	70-80%	More than 80%

This is to allow comparison across seasons. It is important to remember that the potential yield will be based on the seasonal weather pattern so the potential yield in a dry season will be less than a wet season.

Table 1. BYC yield results for 2018

Farm	Factory	Adjusted yield	Sugar_%	% of potential	Day of year drilled	Day of year harvested	Soil class
1	Newark	74.68	18.44	<60	85	320	Light
3	Wissington	90	18.76	>80	113	304	Medium
4	Newark	80.08	17.99	<60	83	365	Light
5	Cantley	79.27	19.25	70-80	107	270	Light
8	Newark	101.84	16.64	70-80	108	389	Medium
9	Bury	109.78	17.80	>80	81	270	Medium
10	Cantley	69.92	18.55	<60	108	368	Medium
11	Cantley	89.16	18.04	70-80	115	327	Medium
12	Wissington	89.81	17.83	70-80	110	334	Medium
14	Wissington	65.5	18.71	<60	109	398	Medium
15	Bury	111.09	18.66	>80	110	347	Medium
16	Cantley	95.28	18.84	>80	127	373	Light
17	TBC	106.19	17.94	>80	111	349	Light
18	Cantley	101.31	18.59	70-80	108	365	Light
19	Bury	74.1	17.77	70-80	109	269	Medium
20	Newark	122.11	18.43	>80	83	326	Light
22	Newark	80.44	18.17	60-70	110	400	Medium
24	Cantley	86.17	18.62	60-70	110	355	Light
25	Wissington	104.03	17.71	70-80	106	351	Organic
26	Newark	81.2	17.92	60-70	110	365	Light
27	Bury	54.86	17.28	<60	125	365	Light
28	Newark	79.87	18.33	60-70	106	365	Light
29	Wissington	90.57	17.65	70-80	97	312	Medium
30	Wissington	89.53	18.22	70-80	110	348	Heavy
32	Wissington	109.77	17.38	>80	108	270	Heavy
34	Wissington	104.56	17.54	>80	112	406	Medium
Average		90.1	18.11%	75%	April 16th	Dec 8th	

Observations on yield

Despite the drought, there were some crops with exceptionally good yields in the 2018 BYC. The overall average of 90.1 t/ha was marginally lower than the average of 97.4 t/ha in 2017.

The overall average yields as a percentage of the potential in 2017 & 2018 were broadly similar across the two seasons.

	Yield t/ha	Yield as % of potential
2018	90.1	75
2017	97.4	73

The drought had clearly limited root growth before September, especially on lighter soil types, with test digs indicating yields of 50-60 t/ha at this stage of the season. The good performance of many crops was due to late season yield production after rain had relieved the drought stress. This highlights a remarkable level of yield resilience in the sugar beet crop when conditions allow.

However, some crops did less well with 20% of crops yielding <60 t/ha. The comparative value in 2017 was 7%. These tended to be lighter land crops and especially where canopies struggled to recover later in the season. This was more acute in areas such as east Norfolk which received less rainfall after the drought.

Sugar levels were generally good across all crops and we know from where more detailed measurements were made, sugar levels declined in many crops in late August and early September as sugar was used to help regenerate canopies, before increasing again.

Many crops were harvested from November (day 300) onwards. The effect of late season crop growth is discussed later, but broadly there was no consistent effect of harvest date on yield. However, remember that this is due to some very high-yielding crops, less affected by the drought, being harvested relatively early and some more severely drought-affected crops on light land being left for later harvesting but unable to recover lost yield.

Not surprisingly, there was an effect of soil type in 2018:

	Yield t/ha	Yield as % of potential
Light	86.0	71%
Medium	93.1	79%

The average yield of the lighter land was 7.1 t/ha less than heavier land but again there is an element of later season yield recovery on some of the lighter soils that would have reduced the average difference between the two if they were earlier harvested crops. In comparison, soil type had little impact in 2017 when soil moisture was not limiting.

The chart below compares yields across the different factory areas. The relatively lower yields reflect the rainfall in these areas, particularly in September when rain arrived later to relieve the drought:

Factory area	Wissington	Newark	Cantley	Bury
2018 yield (t/ha)	92	91	88	87
2018 yield range	65-109	74-122	69-106	54-111
2017	93	87	104	101

Varieties

Twelve different varieties were drilled across the BYC crops with Daphna, Sabatina, Haydn and Bloodhound being the most frequently grown. Four of the fields were drilled with more than one variety.

There were no clear indications of differences between varieties in terms of yield. With such a range of varieties being grown across a wide range of soil types, drilling and harvest dates it is not possible to make 'like for like' comparisons between varieties. As there is only an 8% between the yield performance of varieties in the RL trials, it can be assumed that any effects were overshadowed by other factors in 2018.

Observations about drilling and plant populations

The average drill date was the 18th April, three weeks' later than in last year's Beet Yield Challenge. The earliest drilled crop was the 22nd March and the latest was the 11th May.

There was no effect of drilling date on yields in 2018. Historic data has shown that drilling after the 10th April carries a yield penalty. Clearly, this was not the case in 2019 and suggests we should concentrate less on drilling date and think more about soil temperatures, moisture levels and seedbed conditions.

BYC crops drilled after April 15th (105 days) went into warm soils with plenty of moisture and typically emerged rapidly (within days of drilling in many cases). The patient BYC growers waited until seedbeds dried enough to form ideal seedbeds for rapid early crop growth and crops were at 6-leaf establishment in no time at all. In fact, in some cases the later-drilled crops overtook some of the earlier-drilled BYC crops which had sat in cold & wet soils with poor root development.

Seed rates ranged between 1.1-1.35 units/ha. Wisely, growers kept their seed rate higher for early drilling into poorer conditions whilst some reduced seed rates for later-drilled crops as the expected establishment increased.

Where seedbed conditions were good, there were some very good plant populations. The average was 101,000 plants/ha and higher than the 95,000 average in 2017. Twelve crops had less than 100,000 plants/ha and the lowest plant population was 80,000 plants/ha.

Earlier-drilled crops had lower plant populations of 92,000 /ha indicating that the cold and wet conditions reduced seedling growth and survival. A higher incidence of seedling diseases such as Aphanomyces was seen crops and would certainly reduce the likelihood of establishment.

On average, crops with more than 100,000 established plants/ha performed better that crops with <100,000 plants/ha, reinforcing the importance of plant population as a key driver of yield.

	<100,000 plants/ha	>100,000 plants/ha
Yield t/ha	85.2	91.0
Yield as a % of potential yield	73	77

Observations about canopy development and crop cover

Crop cover was measured by growers, BBRO & BS staff throughout 2018. In some instances, this was by using the Canopeo phone app which gave a quick and relatively accurate method of assessing crop cover. BBRO also analysed a sequence of satellite images to assess canopy progression throughout the season and Omnia Precision Agronomy used satellite imagery to assess canopy biomass at the beginning of September.

Generally, crops drilled later developed canopies very rapidly in the presence of plenty of warmth and soil moisture.

Symptoms of manganese deficiency were common in many BYC crops during periods of rapid growth, but foliar applications of manganese helped alleviate this in most cases.

As soils dried out in the drought period, canopy development slowed, especially on the lighter land, and in more severe cases resulted in senescence of lower leaves, especially where in contact with the hot soil. Magnesium deficiency was very commoly found in BYC crops as the drought developed.

Manganese deficiency in rapidly growing crops

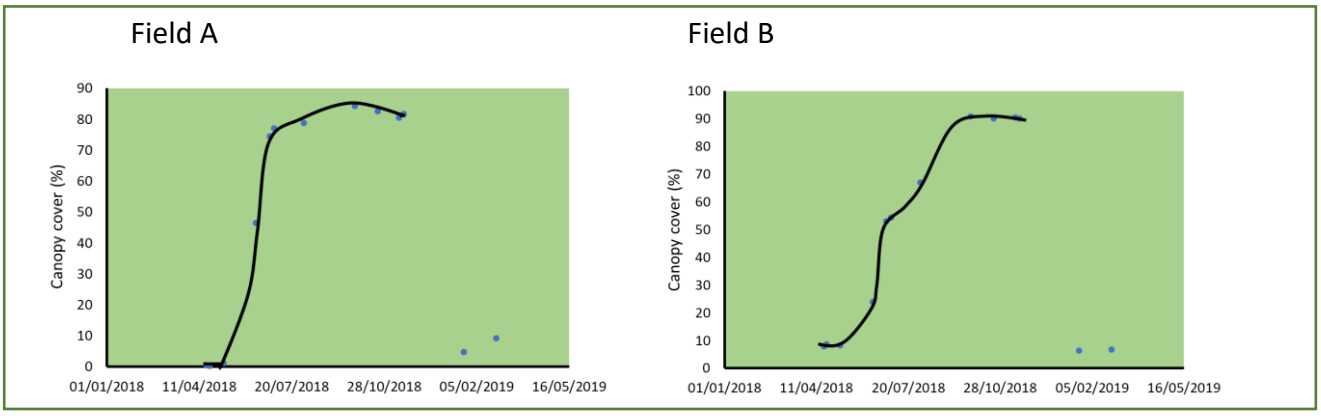
Magnesium deficiency in droughted crops

Between late July and mid-August, canopies ranged between 64-98% crop cover, with severe wilting recorded in many crops. Differences between levels of wilting were clearly related to soil type with medium loams, silts and clay loams less affected. There was no clear evidence of differences between varieties in terms of canopy development at this stage.

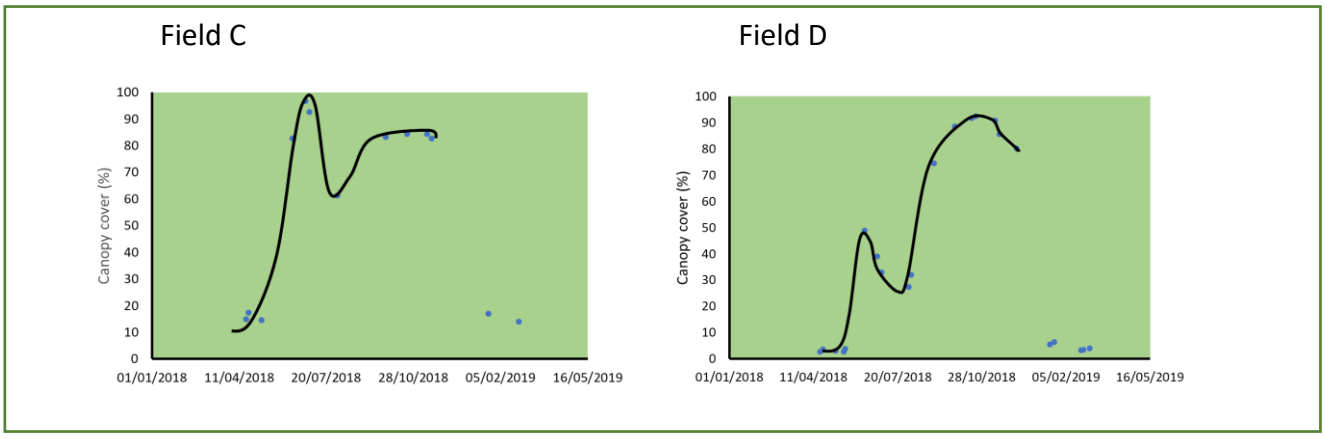
We've included some typical examples of BYC crop canopy progression below. These are based on the satellite-images.

Some crops had relatively unconstrained canopy growth, as in **field A** below, whilst others, as in **field B,** showed some slowing of development, especially in late July and during August. These crops tended to be on medium and silt soil types. Late recovery of canopy cover in September was observed in with over 80% crop cover being reached again by October.

Figure 1 (Fields A-D) Satellite-assessments of BYC crop cover during 2018



Unfortunately, many crops, especially on lighter land, were affected more by the drought conditions and lost crop cover through the senescence of leaves, especially the lower leaves. This can be seen in both **fields C & D** to different extents. **Field C** lost nearly half of its cover having reached full canopy in July whereas **field D** lost 20% of its cover having reached only 50% crop cover by July. Crop cover recovered in both these examples although a further decline was measured at the end of October in **field D.**



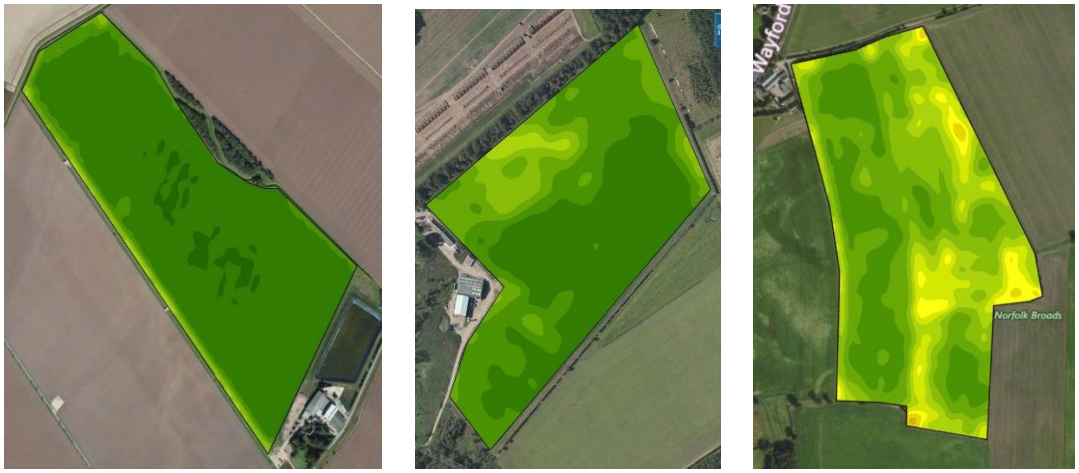
These patterns of canopy growth defined the yield performance of crop in 2018. In particular, the ability of crops to regrow canopies after the drought and to provide a canopy platform to drive late season root growth and sugar production was key.

The remarkable recovery of crop cover is captured by some photographs of BYC crops below:

Satellite images of variation in canopy biomass in September 2018

Satellite NDVI image taken in the first week of September showed BYC crops varied in terms of their canopy biomass within fields. This would have been the period when the symptoms of drought were most pronounced and, in some fields, before crops received rainfall later in September. The images for three different BYC are below, showing a very uniform crop on the left compared with more variable crops on the right.

There was no clear relationship between the level and variability in canopy biomass and final yield in the 2018 data and subsequent canopy recovery will have masked this. It would have been informative to assess canopy biomass again at the end of October. It is not possible to identify the reason for the variance. In some fields, variable soil type may be the cause, in others, soil compaction, pest, weed & disease incidence may be the cause. Many more in-field assessments at different dates would be needed to establish precise relationships. However, it is a fair asummption that in the absence of the late-season canopy recovery, fields with more variable crop cover would have had substantially lower yields.



Above ground biomass sateliite images demonstrating the range of intra-field variation

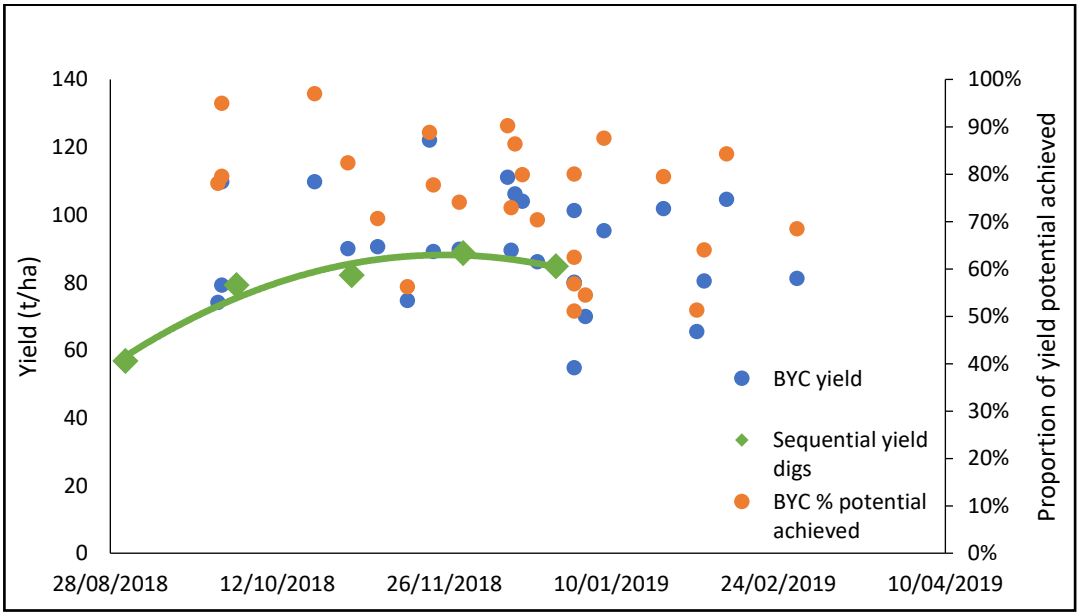
Observations on late season canopy growth, foliage disease control and harvesting.

As highlighted by the canopy growth curves, late-season growth of crops was exceptional in 2018. Where there was rainfall, above average sunshine hours and warmth in late September and October were key to driving both canopy regeneration and root & sugar production.

As most of the BYC crops were harvested later in the campaign and only a few harvested earlier, it is not possible to show the full extent of yield progression over the campaign in 2018/19. However, it was possible to use other data to demonstrate this.

Figure 2 shows the actual yields (blue) and potential yields (orange) at different harvest dates. The green curve shows data from a BBRO sequential yield trial undertaken in 2018 with five harvest dates*

Figure 2 Actual and % of potential yields in relation to harvest date (2018/19)



**Data from Bracebridge Heath on a sandy loam soil type. The data represents the average of eight different varieties, each with four replicates of each variety at each harvest date.*

This green curve indicates that the average yield increase over the period between September and January was 45%. There were differences between varieties, but this is subject to further evaluation and assessment outside of the BYC. There was no evidence from the BYC data of differences between varieties as there were too many interactions of variety with soil type, harvest date and foliage health.

The graph indicates the majority of the BYC crops were harvested after the point that the green curve suggests yield increase had already plateaued. The slow growth at this stage would have been due to lower soil temperatures.

The graph also highlights that some crops, mainly those on more moisture-retentive soils, returned some very high yields at relatively early harvest dates. Conversely, some of later-harvested crops had lower yield levels and, in most cases, these were light land crops which had been left but had not been able to recover their canopies. In some cases, this was a result of a lack of rain, especially in areas such as east Norfolk.

Whilst soil moisture appeared to have an overriding effect on the ability of crops to recover in this period, it is likely that other factors such as soil properties (e.g. structure, compaction and fertility) and canopy health would have been influential.

Differences in canopy leaf regrowth between two crops on contrasting soil types in December

The ability of many crops in 2018 to generate so much yield later in the season (+45%) as well as achieving a relatively high percentages of potential is of significance. This was greater than we measured in the autumn in the 2017 BYC crops with an average increase in yield between first and last harvested crops of 20%. A possible explanation is that in 2018, many crops lost their older leaves during the drought and regenerated a relatively young canopies in September & October; these canopies worked more efficiently, aided by some above average sunshine hours in this period.

Radiation-Use Efficiency (RUE) is a term to describe how efficiently plant can convert light into biomass. It is well understood that younger canopies tend to have a higher RUE, especially when not having to maintain a large canopy with many older inefficient leaves, allowing for more energy to be partitioned to the roots. It is proposed that many beet crops benefited from this in 2018. A further implication of this effect is that in crops growing on heavier fertile soils where canopy growth tends

to be more vigorous than that on lighter less fertile soils, later season yield potential may be less as a higher proportion of energy is needed to maintain the canopy. Comparisons of the top weights of plants between a silt soil and a sandy loam soil in 2018 showed the silt soil developed tops weighing 2.5x heavier than those on the sandy loam site and whilst the silt soil had a highest yield, it increased yield less than the sandy loam. This is an area which warrants further investigation.

It is interesting to note that there were few obvious signs of nitrogen deficiency in this period, indicating that there were enough reserves and mineralisation occurring in the soil to drive the canopy re-growth without a requirement for additional N. It was not possible to assess the impact of availability of other nutrients at this stage.

Overall, an assessment of canopies prior to harvesting showed that healthier and more vigorous canopies prior to harvest were associated with 5% higher yield and a higher % of potential compared to crops judged to have less vigorous and healthy canopies. Clearly, for a late-season canopy to function most effectively it needs to be healthy.

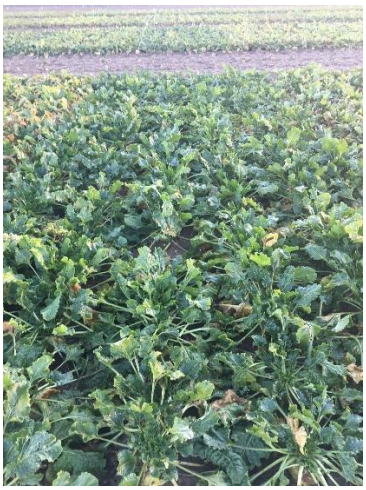
Foliage disease

Generally, foliage disease levels in 2018 remained low during the drought stage but increased from October onwards (September was relatively dry) This was mainly due to rust & some limited Cercospora development.

Remembering that 85% of the crops were harvested after the 1st of November 70% of BYC crops had two fungicides, which generally held disease levels in check. This is line with BBRO advice.

However, 23% of crops receiving a 3rd fungicide on average returned a higher yield (97 t/ha versus 88 t/ha) and achieved more of their potential. Crops receiving 2 or 3 fungicides were, broadly, on the same soil type and had similar harvest dates. This highlights the value of a third fungicide in later-harvested crops and is presumably linked to improved disease control.

Differences in disease levels on different varieties with fungicide protection was observed but no clear trends on yields was shown by the BYC data. However, BBRO trials in 2018/19 showed some clear differences between varieties.



BBRO trials showing the foliage in January 2019 of two different varieties after two fungicide applications.

BBRO Checking harvest losses

Early harvests were made challenging due to the dry conditions, and crowning and surface losses were higher initially but, following rain conditions, improved by the time most of the BYC crops were harvested.

Over the campaign, average surface losses were 0.38 t/ha and root breakage losses were 2.73 t/ha. These are slightly lower than those measured last year.

Analysis of different agronomic management regimes

We collected data on several different aspects of different agronomic practices and have analysed this data for any relationships. We have attempted do this by soil type, as many agronomic practices are likely to soil type dependant, but, in some instances, there are too few fields in each to allow proper analysis. The key observations are as follows:

Cover crops preceded 25% of the crops. However, the inclusion of a cover crop was not seen to be related to the final yield although the established plant population count was slightly higher where a cover crop was grown before the sugar beet. This was analysed separately for both light land fields and medium/heavy fields, but no difference was found.

Where organic manures were applied ahead of the beet on light land the average yield was 90.5 t/ha and 78% of the potential yield. This was higher by 4.5t/ha than where no organic manure was applied (86.0 t/ha). On heavier land this difference was slightly less pronounced. There was no effect of the use of organic manure on established plant populations.

There was no clear relationship between soil nutrient indices and yields although some pH results indicated some low values (<6.5) which potentially could reduce yields.

Where straw was incorporated the average yield was 94.6 t/ha and 80% of the potential yield. Where straw was removed, the yield was 87.2 t/ha and 73% of the potential. Straw removal was not related to soil type.

80% of the fields were ploughed before sugar beet. There was insufficient detail and examples of other cultivation practice to undertake any analysis.

For most participants, the field last had sugar beet 4-5 years ago. There were some fields where sugar beet was last planted more than ten years' ago and a few fields that had never had sugar beet. However, there was no clear effect on the number of years between beet crops and yield.

Some final thoughts:

- Despite the challenge of the drought in 2018, the BYC crops have highlighted some new trends and information as well reinforcing some established messages from 2017.
- The ability of the canopy to recover from drought and substantial loss of leaf cover in 2018 was remarkable and has given us some pointers to how best to manage canopies to achieve optimum late season growth
- Results reinforce the vital role of soil condition and health in crop establishment and supporting canopy function and have pointed to some new aspects of management that require further investigation.
- Patterns of canopy growth are key to understanding crop performance and we need to explore how we can monitor crops more effectively to translate data into action.

One of key questions asked about the BYC is what do the growers achieving higher yields do differently? Here are some SPOTLIGHTS on the practices that we believed helped unlock the potential of the **2018** crop……

- Growers who ensured soil conditions were right before for drilling rather than drilling by date, benefited from rapid plant development and higher plant populations. Higher yields were associated with crops with a population of 100,000/ha or more.

- Soil type had a clear impact on the susceptibility to drought with substantial loss of crop cover on the lighter, lower organic matter soil types by the end of August. Whilst it was not possible to precisely link practices such as straw incorporation, use of cover crops and reduced tillage to higher yields, there are indications that these had positive benefits in 2018.

- However, it was possible to demonstrate that growers who applied organic manures in 2018 achieved higher yields, especially on lighter land.

- Sugar beet crops demonstrated remarkable yield resilience to severe summer drought through late season growth. Growers who were able to leave drought-affected crops for later harvesting benefited from this.

- Leaf regrowth in September resulted in highly efficient canopies, increasing yields by 45% between September and January. Rainfall was key but ensuring soil structure and fertility could support growth in the autumn was also important. In some fields, smaller regenerated canopies were more efficient than larger established canopies which had been unaffected by the drought. Managing crops for optimum partitioning to roots is a clear target for later harvested crops.

- Maintaining canopy health was key to ensuring late season yield production was optimised and fungicides were key to this.