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‘It never rains in a dry time’ – how does sugar beet survive drought and how can we help it?

It was impossible to ignore Summer 2022’s record temperatures, lack of rainfall and the impact this had on sugar beet crops. July was particularly dry with the UK seeing just 56% of the average rainfall for the month. This made it the driest July in over 20 years and other than February all the preceding months were drier than the long-term average[1]. So how do plants cope with reduced water availability and what can we do to help?

Fig.1. A sugar beet crop in central Norfolk in late August, early and late September, showing recovery of the canopy after drought

In many ways the response of plants to drought stress is like dehydration in us. In the human body the kidneys detect dehydration through a reduction in water volume and stimulate the release of the antidiuretic hormone (ADH), whilst in plants the roots sense a reduction in water uptake and trigger the release of abscisic acid (ABA). These hormones trigger a number of responses focusing on reducing water loss and maintaining function. The key changes in the body are that sweating stops and less urine is produced, whilst in plants the stomata close to prevent water loss which in turn increases temperature. It is this increase in temperature that can be particularly damaging. If you imagine yourself dehydrated on a cold day you would be able to function much more easily than on a hot day when you would quickly become lethargic. This is because at high temperature many of the processes in organisms are hindered or stopped. In plants this is significant because photosynthesis stops so there is no longer any growth, this combined with a lower water content is why moisture stressed plants are smaller. In crop plants this is a particular concern as it leads to reduced yields.

Just as people differ in their tolerance and response to dehydration so do different plant species. With its maritime heritage sugar beet has greater drought tolerance than many other arable crops. This means that it can continue to keep its stomata open

Fig.2. Sugar beet in very dry, cracked soil

longer as water availability falls. This may be why sugar beet wilts transiently during the day as it will continue to lose water through the stomata even when water uptake cannot match transpiration. This isn't necessarily a negative trait as it means that the sugar beet is able to continue to uptake CO_2 and photosynthesise for longer than more conservative species which close stomata sooner. As well as keeping stomata open for longer sugar beet also have numerous small stomata which can open and close quickly in response to changes in the environment when needed. Most importantly this means that when light levels and therefore photosynthesis reduce, such as changes in cloud cover, stomata can close to ensure water is conserved. The ability of sugar beet to better match stomatal control to the environment makes them more water use efficient and ensures they are maximising yield with the water that is available. There is limited evidence from my PhD studies that there may be differences in stomatal size and density between commercial sugar beet varieties and this may be linked to canopy architecture, but this requires further research[2]. Additionally, unlike cereals which senescence rapidly when water stressed, sugar beet can continue to grow later into the year recovering some yield when rainfall returns. The challenge here, however, is that the sugar stored in the tap root is also the source of energy for canopy regrowth following leaf loss during drought. BBRO are currently looking at data from this season to see how much sugars changed after the drought period to identify how much sugar was lost during recovery but also if this was regained later in the season. The transition of the crop from drought to recovery was evident across the growing area as shown by the crop monitored by BBRO in figure 1.

Despite sugar beet being relatively drought tolerant and efficient in its use of water, yields are clearly still reduced due to a lack of it. Yield reduction due to water stress varies from 10-25% in the driest years showing how significant an impact drought can have. The characteristics already outlined are out of the control of the grower so what can be done to avoid the impact of drought on the crop?

What can be done at establishment:

1. Ensure rapid establishment, this ensures that the canopy closes quickly and prevents moisture loss from the soil surface
2. Reduce soil movement to preserve water throughout the soil profile
3. Ensure soil is free from compaction so plants can root deep into the soil profile; sugar beet can grow roots 2m deep which ensures water availability when rainfall levels are low and the soil is starting to dry
4. If using a cover crop ensure timely destruction to prevent the cover crop removing water from the soil before the sugar beet
5. In the longer term the use of organic manures to increase soil organic matter can increase the water holding capacity of the soil, but the benefit will vary depending on soil type[3,4]
6. Increasing drilling depth to place the seed into moisture is an option but seed should not be drilled more than 5cm deep.

What can be done later in the season:

1. Ensure foliar diseases are detected and controlled early to protect the canopy ensuring good soil coverage to prevent moisture loss
2. Irrigating sugar beet in a dry June or July can be beneficial if water, equipment and labour are available.

Most of the management options to alleviate drought are possible at establishment whilst there are few options later in the season. The opportunities to preserve water and ensure the crop is resilient to drought at establishment are important as drought early on can devastate a crop by preventing germination or killing young plants, leading to a poor plant count and low yields. However, drought can occur through the spring and summer months and with only around 5% of beet growers having the choice to irrigate more options are needed for growers. For this reason, BBRO is working with breeders to identify whether drought tolerance varies between the UK RL varieties and also testing these alongside varieties bred specially for climates with poor water availability, to see if these could be a viable option for UK growers in drier areas or soil types in the future.

Fig.5. In-field BBRO drought trial testing RL varieties to identify if drought tolerance differs with plants taken through to yield

Overall sugar beet is more drought tolerant than most other UK arable crops but can still see significant yield losses in the driest years. Ensuring soil moisture and free rooting is promoted through optimal management practices at establishment will reduce the risk of drought but the identification of varieties with greater drought tolerance will provide another option in the growers arsenal.

References

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[3] Hudson, B.D., 1994. Soil organic matter and available water capacity. Journal of soil and water conservation, 49(2), pp.189-194.

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Fig.3. Sugar beet being irrigated in the Brecks, Norfolk

Fig.4. BBRO drought seedling screen to identify if some varieties grow better under drought at establishment