PDA NEWS
September 2023

Potash nutrition of Cereals

Potash affects both yield and quality of grain as well as the general health and vigour of the plant. Cereal crops need at least as much, if not more, potash than any other nutrient including nitrogen. Potash is needed in such large amounts because it is the major regulator of solution concentrations throughout the plant. It controls cell sap content to maintain the turgor of the plant and supports the movement of all materials within the plant. Potash supply is thus essential for all nutrient uptake by the roots and movement to the leaves for photosynthesis, and for the distribution of sugars and proteins made by the green tissue for plant growth and grain fill.

The practical implications of shortage of potash are summarised in the following table:

Deficient K
Low yield
Inefficient nitrogen response
Increased risk of nitrogen loss
Reduced 1000 grain and specific weights
Reduced grain ripening duration
Fewer grains per ear
Poorer grain sample
Weaker straw
Increased risk of lodging
Increased susceptibility to drought
Increased pest and disease susceptibility

Effect on cereal yield components

Adequate available potash is essential to produce high-quality marketable grain with good specific weight and well filled grains. A shortage will result in premature ripening with significantly lower individual grain size and weight and will also prevent some potential grain sites from developing, thus reducing the number of grains per ear (see the table below).

	Level of Potash		
	Deficient	Intermediate	Sufficient
Days from flowering to ripening	46	68	75
Grain number per ear	36	38	43
1000 grain weight (g)	17	33	34

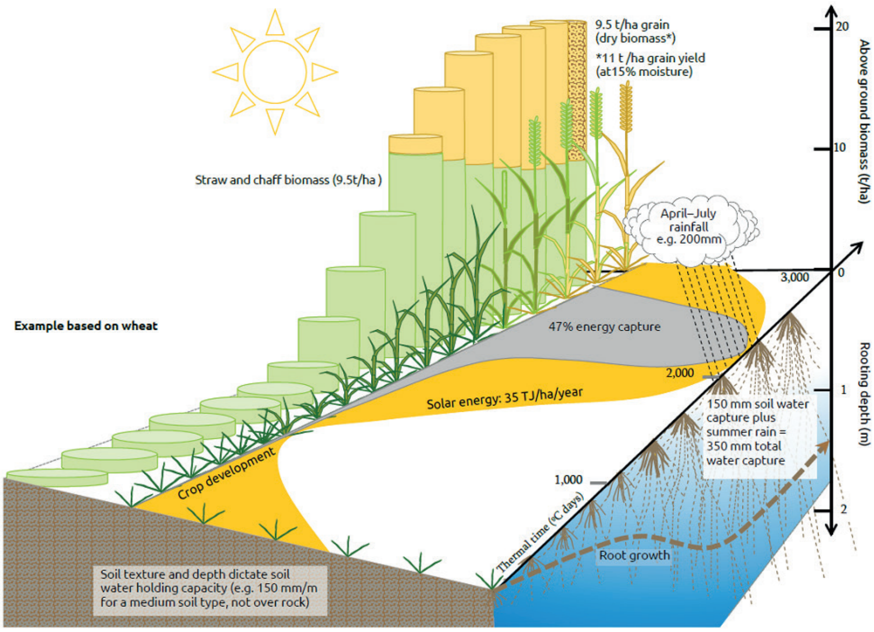


Figure 1. Summarises the capture and utilisation of natural resources, particularly solar energy, water and carbon dioxide in wheat. It illustrates how these resources convert into grain and non-grain energy (expressed here in t/ha biomass or grain). It also introduces the concept of 'thermal time', which represents the time taken for the crop to move from one growth stage to the next, based on the cumulative heat received. Source: ADAS

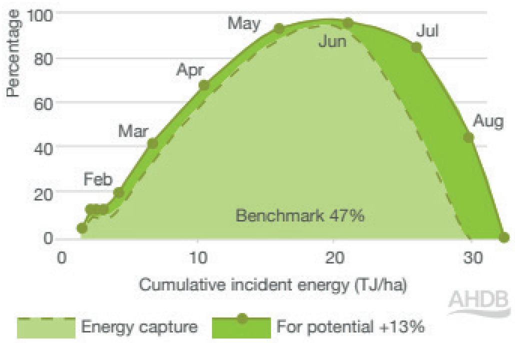


Figure 2. Typical solar energy capture by wheat crop grown in the UK. Potential to increase season-long energy capture to 60% (+13%) also shown. Source: ADAS

Cereals convert natural resources, including water, solar energy and carbon dioxide into grain (figure 1). With light being one of the most common limitations for crops in the UK in most seasons, the more light is intercepted, the higher the yield. As cereals are annual crops, they are not able to capture sunlight all year, and measurement data carried out by ADAS would suggest that crops in the UK have the ability to capture up to 60% of the season-long energy (figure 2). The current AHDB benchmark within the Wheat Growth Guide is based on 47%, and although there is some opportunity for improvement early in the season, most of the 'lost' solar energy occurs later in the season, as crops begin to senesce.

The canopy starts to senesce from June onwards, but the speed of senescence will depend on a variety of factors, including moisture availability. Whilst there is little that can be done about the weather (unless irrigation is a viable option), one of the variables that can be controlled is the supply of potassium to a crop. The level of potassium available to a crop can have a dramatic impact on the speed of crop development from flowering through to ripening. Measurements taken from three soils with varying levels of potash showed crops that were well supplied with potassium took 29 days longer to fully senesce than crops that were deficient. This represented a 64% increase.

With moisture limitations becoming more likely towards the end of the season, one of the reasons for the big difference in speed of ripening from potassium deficient crops is likely to be related to the nutrients impact on stress. Moisture stress significantly reduces growth and accelerates leaf senescence due to the reduced time to translocate metabolites from leaves to grain, which ultimately affect grain yield and quality. Delayed leaf senescence can therefore facilitate plants in remobilising nutrients from old senescing leaves to young leaves and the developing grains.

The maintenance of a favourable water status is critical for plant survival under drought stress. Osmotic adjustment is a major trait that is associated with maintaining cell turgor pressure and water retention in response to drought stress. As the plant preferred ion, potassium plays a key role in maintaining the water content and hence turgor pressure of each cell, even under drought conditions.

Plants also depend on potassium to regulate the opening and closing of leaf stomates (tiny apertures on the underside of leaves). The stomata are important for allowing the movement of carbon dioxide into the plant, whilst releasing oxygen. The plant regulates the opening and closing of the stomata through movement of potassium into or out of the guard cells. When potassium moves into these cells, they accumulate water as a result of their higher salt concentrations (through osmosis) and therefore swell, opening the pores. During drought stress, quick stomatal closure and internal moisture preservation are essential for plant adaptation to drought conditions. If potassium levels within the plant are low, the stomata become slow to respond and do not close as quickly, resulting in the loss of water vapour which if not corrected, could lead to premature crop senescence.

Grain Number and Weight

The yield of a grain crop depends on (a) the number of ears per unit area, (b) the number of ripe grains per ear, and (c) the weight of the grain. There is significant interaction between all three elements, and although increasing all three may theoretically result in an increased yield, the reality is that increasing one will inevitably lead to a reduction in another. For example, high ear numbers can result in shading, which leads to fewer grains in each ear.

Due to its influence on photosynthesis and assimilate transport, potassium is particularly effective in the improvement of grain number and grain weight.

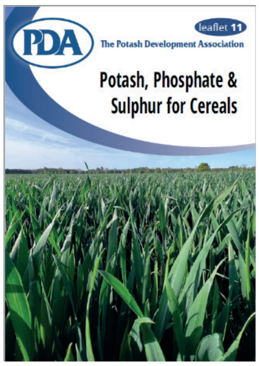
According to the AHDB Wheat Growth Guide, the benchmark for grain number per ear is 48. With 460 surviving fertile shoots/m^2, this gives 22,000 grains/m^2. Cool, bright conditions – especially one or two weeks before flowering – can prolong or enhance the ear formation period and increase grain number per ear. However, inclement weather at flowering, such as heavy rain, heat or drought, can impair pollination and reduce the number of fertilised florets.

Adequate potassium levels in plants leading up to anthesis can reduce the shading stress in wheat, potentially through changing the ability of chlorophyl to intercept light and therefore enhance photosynthesis.

Grain filling starts when flowering is complete and continues until grain reaches about 45% moisture. Grains accumulate more water than dry matter for about four weeks after flowering, when water content is at its maximum. Water enables cells first to divide, then expand. Severe drought or disease can significantly reduce grain size. As water uptake stops, dry matter accumulation accelerates. Rapid dry weight growth continues with starch and protein deposition in expanded grain cells – these are supplied by both photosynthesis and redistribution of reserves. Suboptimal photosynthesis during the first two or three weeks of grain growth reduces the cell number and potential weight of each grain.

More carbohydrate is produced during the construction phase than is required by the plant, therefore these stored reserves are utilised during grain fill through redistribution within the plant. Adequate potassium levels are required to maximise the production of these carbohydrates (linked to the impact on stress and photosynthetic rates within the plant), but also to help translocate these carbohydrates to the grain. In times of moisture stress, these reserves are even more important in maintaining high yields.

The PDA Cereal leaflet has recently been updated and a copy has been included with the newsletter providing a comprehensive review of phosphate and potash nutrition for cereals as well as exploring the benefits of sulphur and magnesium.



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