POTASH NEWS

December 2022

Plant Potassium Measurements

The Fertiliser Manual (RB209) makes recommendations for Phosphate and Potash based on the Index system, where soils that are at or above the target level should have sufficient levels of nutrient to support the growth of that year's crop. At soil index 2 applications should be made to replace the nutrient that is removed, for sustainability. This has over the years, proved to be the most efficient means of ensuring soils have sufficient available nutrient to optimise crop growth each year, however this one-off assessment may need monitoring to ensure this remains the case for each specific soil type and across the years between sampling and even within fields.

1. Visual crop symptoms

The most basic method for monitoring potassium levels and identifying deficiency would be through a visual assessment. For nutrients in general, waiting for deficiency symptoms to become visible may be too late as crops can appear to be perfectly well fed yet still be deficient. This 'invisible' deficiency is often referred to as 'hidden hunger', a problem illustrated in Figure 1. The result of such unseen deficiencies may be a reduction in yield or quality, which is often attributed to other causes such as the weather, or even accepted as the norm.

When K is deficient, several processes are impaired. Low K inhibits enzyme activation, making plants more susceptible to fungal attack. Impaired stomatal activity results in poor control over gas exchange, impairing photosynthesis and water control, making plants more susceptible to stresses from drought, frost, water uptake, and soil salinity. Low K also impairs proton (H^+) exchange across membranes in chloroplasts, resulting in worsening symptoms under higher light intensity. Transport of photosynthates can also be impaired, resulting in a build-up of sugars (potentially worsening aphid attacks) and a reduction in protein and starch synthesis, lowering the plant's dry weight. Impaired lignification may result in weaker stalks and increased lodging. Potassium is an abundant cation (K^+) found in the cytoplasm, providing cell turgidity and rigidity by maintaining the osmotic potential. The visual evidence of all these processes may be very difficult to identify, particularly without a sufficiently supplied crop to compare against.

Any infield tests for potassium sufficiency should meet four basic requirements:

1. It is easy and inexpensive to carry out
2. It gives a definitive answer on sufficiency/ deficiency
3. The timing of measurement and turnaround time gives growers the opportunity to respond
4. It allows management practices that give a high level of successes

There are several methods by which the crops potassium status can be measured.

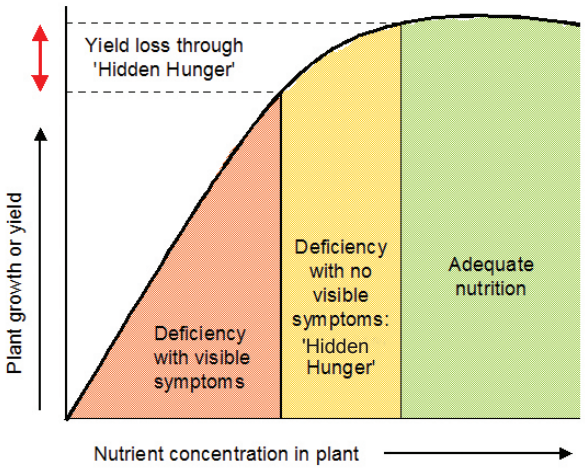

Figure 1: Yield reduction caused by 'hidden hunger' despite there being no apparent deficiency symptoms.

Potassium deficiency may first appear as deep green plants with shorter and fewer internodes and smaller leaves, followed by the rapid development of necrotic spots along the margins and across leaf blades of recently matured leaves.

2. Light reflectance

Potassium deficiency can cause changes in both individual plant organs and, collectively, the crop canopy. When leaf tissue becomes chlorotic or necrotic, it no longer reflects light the same way it did when it was healthy. Visibly, leaves change from green to yellow or brown, but changes also occur outside the visible spectrum. These changes can be identified by measuring the reflectance of the crop using specific wavelengths which can then be linked back to the potassium status of the plants (Figure 2).

Light reflectance in this form is currently used on farm for measuring a crops nitrogen status to variably mange nitrogen inputs.

Although there is work that has been carried out to link reflectance to a plant's potassium status, the major difficulty that has yet to be overcome is the ability of reflectance to discriminate between more than one nutrient, making this an unlikely method for use on farm.

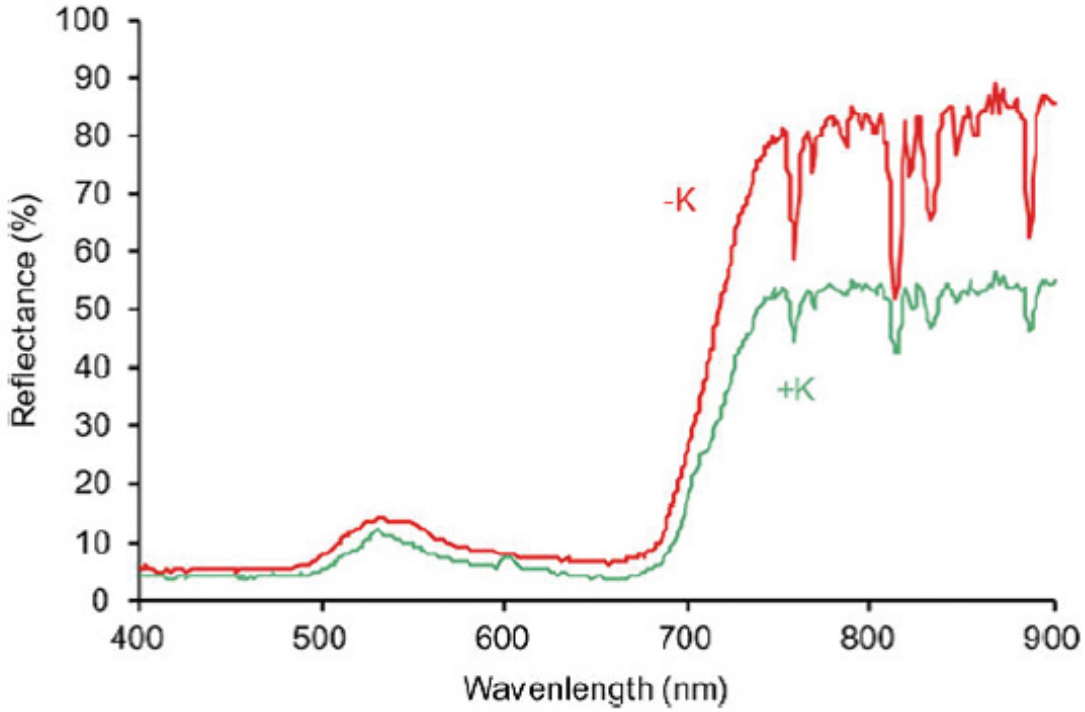

Figure 2. Reflectance spectra for wheat (Triticum aestivum L.) without K (K) and with K (+K), and all other nutrients at sufficient levels. (adapted from Ayala-Silva and Beyl 2005)

3. Leaf tissue analysis

The most common method for identifying deficiencies in crops and grass is tissue analysis, measured by the laboratory on samples collected from the field. After the laboratory receives the samples, they are oven dried, then ground. A small subsample of the ground material is weighed out and digested in solution. To interpret the results, tissue test results need to be correlated to crop performance, typically yield. The stronger the correlation, the more useful tissue analyses become as a diagnostic tool. Crop quality and plant health could also be important performance measures by which to interpret the results.

Although tissue analysis is the most common means of measuring nutrient levels in plants in the UK, it may not be the most appropriate for potassium, as most K is held in the 'liquid' fraction of the plant, not the dry matter. For this reason, it may not provide a reliable means of avoiding deficiency in the season of testing, but could be used as an addition to soil analysis or as an extra diagnostic tool in specific circumstances.

4. Sap analysis

Another approach to analysing the potassium status of plants is to measure the content of the plant sap. As potassium is held in solution within plants, rather than within the dry matter, sap analysis can be a more accurate method of measuring potassium levels. Percent K in dry matter varies widely with season, stage of growth, part of plant, fertiliser (nitrogen or potash) application and weather or other factors which affect nutrient uptake and rate of growth.

Work at Rothamsted Research funded by the AHDB has indicated that adequacy of potash in winter wheat is represented by tissue water concentration in leaf 1 (the youngest mature leaf blade) between 5.8 and 7.8 g K/litre (150 and 200 mM K) for growth stages between GS31-61 (Figure 3). Plant concentrations below this range may result in yield penalties. If a sap test is not carried out in the field care must be taken to avoid any loss of moisture from the sample before analysis in the laboratory.

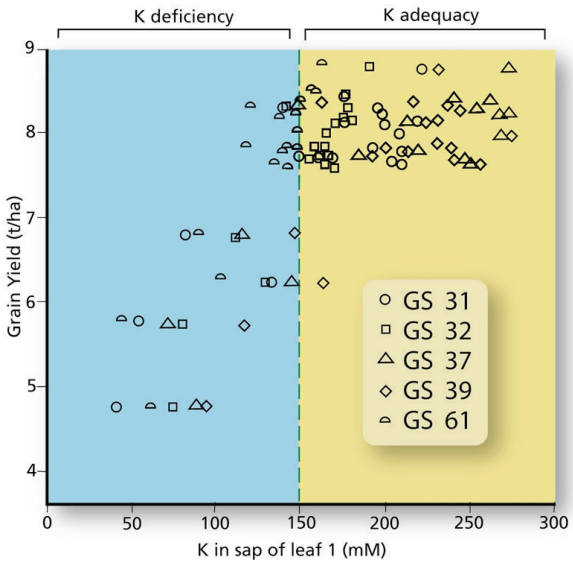

Figure 3. Potassium in leaf sap of winter wheat

Summary

Infield measurements for plant potassium levels are only likely to help monitor the effectiveness of the current fertiliser strategy based on maintaining soils at the target level of 2- for arable crops and grass. This has been shown to be the most effective method for providing sufficient quantities of plant available nutrient throughout the growing season to ensure optimum yield and quality.

Nutrient deficiency correction

If soil Indices are below the target level the PDA P&K Nutrient Calculator provides a guide to the quantity of nutrient which is likely to be required to correct the deficiency. This will vary according to the level of deficiency and the soil type. The quantity will usually be more than can reasonably be applied in one season, and the Calculator asks by how much and how quickly you want to correct the deficiency, i.e. over how many years. The desired improvement can be input by Index or more precisely by mg/litre as determined by soil analysis. Once all relevant information has been input (for one or both nutrients) clicking on the 'Calculate' button will provide a guide to the total quantity of nutrient(s) which will be required. The annual dressing is also shown, according to the timescale selected. The bottom line shows this annual deficiency-correcting application, together with the maintenance dressing. The cost of the nutrient(s) required to correct the deficiency should not be charged to the crop being grown but should be accounted for separately.

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