**Site description**

Fieldwork was conducted on feed winter wheat (*Triticum aestivum* L.*)* variety Graham during a nutrient application field trial in East Yorkshire, UK (latitude: 54.0929, longitude: -0.6803) in June 2021. The soil type is silty clay loam over chalk, with the previous crop being winter oilseed rape. The annual average temperature is 12.4 °C, with an average maximum temperature of 20.0 °C, from a 1991-2020 climate period. The average annual rainfall is 771.16 mm.

For the field trails, plants were given treatments of Nitrogen fertiliser, with additional Sulphur/no Sulphur addition and a sucrose/no sucrose addition (Table 1). The N fertiliser applied was Nitram (CF Fertilisers, UK). Sulphur was added to some N treatment plots in the form of ammonium sulphate to promote N uptake at tillering, GS30 and GS33. The N in the ammonium sulphate was accounted for when calculating how much ammonium nitrate to apply to reach the target N rate treatments. Where sucrose was added, it was applied twice during tillering, and at GS30. Each treatment plot was 2.1m x 24 m in size. For N treatments, 290 kg/ha was applied across the growing season, for additional Sulphur treatments 50 kg/ha SO3 was added across the growing season.

**Ground measurements**

Field measurement campaigns to were conducted from 6th June - 10th June 2021. All measurements were collected on the same leaves in each plot.

**Leaf gas exchange**

Field measurements of leaf-level gas exchange were carried out using a LI-6800 portable infrared gas analyser (LI-COR, Lincoln, NE, USA). Flag leaves were used for all measurements including assessment of chlorophyll and nitrogen analysis. The LI-6800 was fitted with a 6400-02B Red/Blue Light Source, and CO2 response curves (A–Ci curves) were produced under light-saturating conditions, at photosynthetic photon flux density (PPFD) levels of 1800 μmol m−2 s−1, and stepwise CO2 concentrations of 420, 200, 100, 50, 25, 420, 420, 600, 800, 1000, 1200, 1500, 1800 μmol CO2 mol−1 air. Prior to logging measurements, leaves were acclimated in the chamber at 1800 μmol m−2 s−1, 60% relative humidity, a temperature of 25°C and a CO2 concentration of 420 μmol CO2 mol−1 air until steady-state conditions were reached. Throughout the measurement sequence, the leaf chamber was maintained as close to 25°C as possible (approximately ±1°C) and relative humidity was set to 60%. A complete *A*/*C*i response curve took approximately 1 h to perform.

**Leaf biochemical analysis**

Leaves were sampled, placed in open plastic bags and kept at a temperature of 0°C during transport back to the laboratory for subsequent biochemical analysis to extract leaf chlorophyll and leaf nitrogen content. Foliar chlorophyll was extracted using spectra-analysed grade *N,N-*dimethylformamide, and absorbance was measured at 663.8, 646.8 and 480 nm using a UV-2600 spectrophotometer with an accompanying 6-cell CPS-100 cell positioner (Shimadzu, Kyoto, Japan). Leaf samples were dried at 80°C for 72 h and ground to a powder in a tissue lysis machine using metal 3mm ball bearings in 2 ml microcentrifuge tubes. Isotope analysis of % nitrogen content was obtained.

**Leaf hyperspectral reflectance**

Hyperspectral leaf reflectance from the adaxial surface of all sampled leaves was collected using a Spectral Evolution PSR+ 3500 spectroradiometer (Spectral Evolution, Inc. Massachusetts, USA), with a leaf clip attachment and internal calibrated light source. Spectra were automatically corrected for dark current and stray light, and referenced against an integrated Spectralon white reference standard (Labsphere, New Hampshire, USA). The PSR+ 3500 samples spectral radiance from 350-2500 nm across 2151 channels, for each measurement 25 spectra were internally averaged to increase the signal-to-noise ratio of the data.