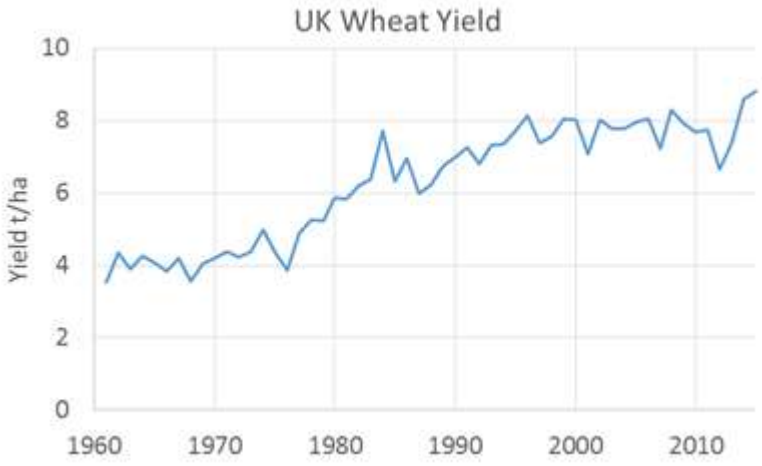
A Field of Wheat

YEN at Middle Field;

Collective Member Daniel Kindred talks about predicting yields on Middle Field.

Wheat yields in the UK doubled between the 1960 and the 1980s as a result of advances in soil management, breeding, crop protection and fertiliser use following years of research and investment when feeding the nation was seen as a national priority after the war. However, since the 1990's yields have plateaued. The causes for this plateau are hotly debated but coincide with greatly reduced public investment in agriculture and research, low prices & profitability and an emphasis on reducing environmental impacts and reducing fixed costs. Its been recognised since the food price spike in 2007 the need for increased productivity to meet increasing global food demands without increasing the amount of land brought into production from nature… and without increased environmental impact. Hence the term Sustainable Intensification was coined.



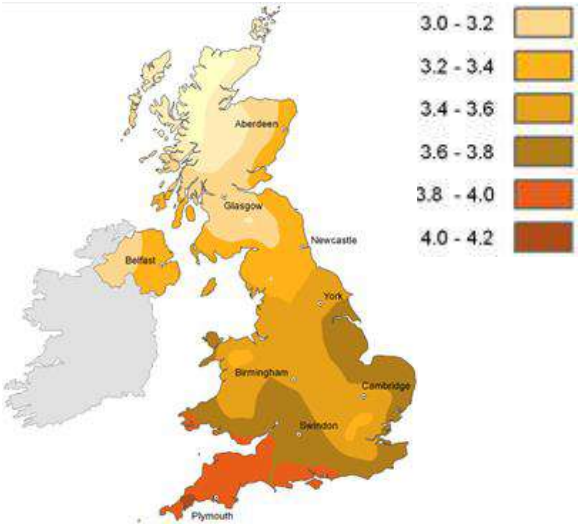
Wheat yields for UK since 1961.

In 2012 ADAS set up the Yield Enhancement Network (www.yen.adas.co.uk) with growers and the arable industry to better understand limitations to yield and to develop ideas and innovations to overcome them. Crop yields are not fundamentally a result of the inputs 'bought' by the farmer such as seed, fertiliser and agrochemicals, rather they are driven by the capture and conversion of the 'free' resources of light, water and carbon dioxide. In the YEN we estimate potential yields for farmers fields across the UK from available light and the water available from the soil.

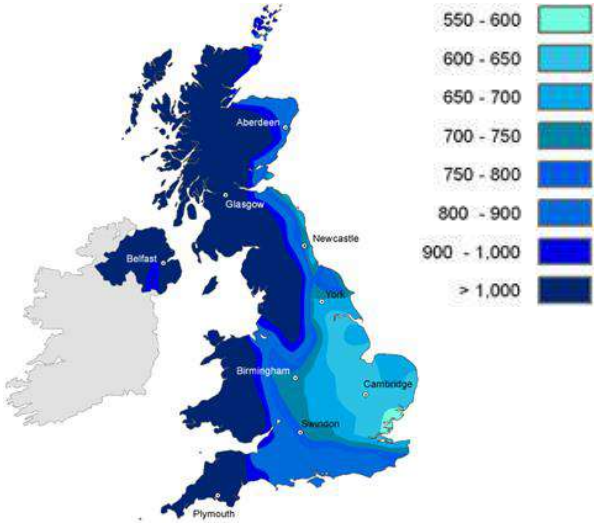
In the UK we receive between 30 and 40 Terra Joules per ha (TJ/ha) of light energy in a year, more in the South than in the North. For the 'Field of Wheat' farm in Lincolnshire average annual solar radiation is 37 TJ/ha, that's the equivalent of the annual electricity use of around 2500 homes. Wheat is sown in September and harvested in August. It takes time for the crop to establish a full canopy of leaves, and

the crop senesces and dries out for a period before it can be harvested, so the crop can't capture all the light available in the year. We estimate the maximum amount of light a wheat crop could intercept in a year is 60%, so 22 TJ/ha for our Field of Wheat. Plants use light to convert carbon dioxide to biomass through photosynthesis with a maximum efficiency of 1.4 t/TJ, so for our Field of Wheat has the potential to produce 31 t/ha of above ground biomass. Of this biomass a maximum of 60% can be grain (60% Harvest Index) as at least 40% dry matter is requires for the stems and leaves that end up as straw. Grain is sold at 15% moisture content so this gives a maximum potential yield for our Field of Wheat of 21.9 t/ha. This however assumes that the crop has sufficient water available to support this growth.

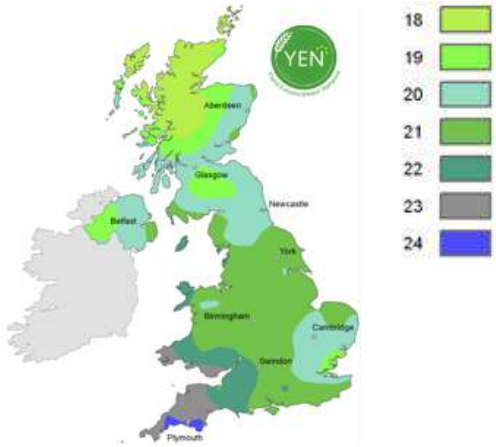
Crops use water through transpiration at a rate of 200 litres per kg biomass produced, or a maximum of 5.5 grams biomass per litre. To produce a biomass of 31.5 t/ha our crop would need to use 5600 t of water per ha, or 560mm rainfall. Annual rainfall in the UK varies from less than 600mm in the East to over 1000mm in the West (see map). Total Annual rainfall in Lincolnshire is 630mm, but much of this falls in winter and drains away so is not useable by the crop. The field has a peat soil which in principle can hold alot of water, about 30% of the volume in the topsoil and 20% in the subsoil. (Sandy soils hold around 12% in top soil, clays around 17%). Crop roots can go down to 2m and deeper, so the soil can hold 260mm of water for the crop. Summer rainfall from April to July is 210mm, so the crop has a total of 470mm water potentially available to it for the period of maximum growth in the spring and summer. In principle this is just enough to meet the requirements of the crop, but in reality peat soils tend to dry out easily and crops often suffer drought.



Long term average Solar radiation in the UK



Long term average Annual rainfall map

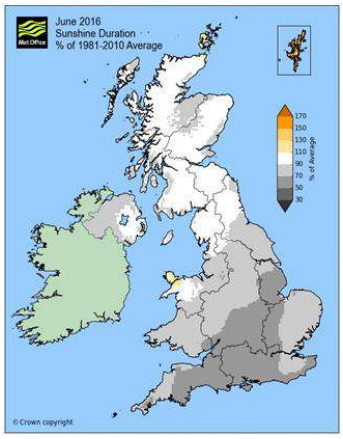


Long term average Yield Potential (t/ha)

Of course, yields achieved on farm generally fall well short of the 20 t/ha we calculate as potential yield - this relates to a perfect variety and management that captures all the potentially available resource and converts it with maximum efficiency - the varieties and systems to achieve this don't yet exist. It does however give us confidence that substantial further yield improvement is still possible in the UK, despite UK wheat yields already being amongst the highest in the world (world average wheat yield is around 3 t/ha). Average UK yields on farm are around 8 t/ha, though many farmers achieve considerably more than this. Bright weather through spring and summer 2015 gave exceptional yields, with a YEN farmer in Lincolnshire breaking the previous world record with a 16.5 t/ha crop. This was

getting close to his potential yield of 21.0 t/ha.

So what are the prospects for yields this year? We certainly don't seem to be in fora repeat of the high yields seen in 2015. June 2016 was wet and dull, with light levels down by over 10%. This has resulted in poor yields of oilseed rape and barley which are harvested in July. Wheat uses the light in July, which was brighter, so fingers are crossed that yields will be OK. The higher than average rainfall in spring and June this year means that crops should generally have had enough water, even in the East and on soils that are usually limiting.



Within the YEN we try to understand what is limiting yield through monitoring of the crops through the season and measurement of the crop at harvest. Peter took digital photos from the crop in June from which we count ear population, using a piece of A4 paper for scale.

The Field of Wheat

We will analyse grab samples of around 100 shoots from the Field of Wheat to determine yield components (grains per ear, individual grain weight and ears per square metre), harvest index, biomass, grain protein content, straw nitrogen concentration and nitrogen uptake.

We are also looking to use satellite imagery to monitor progress of the crops, toassess how quickly in

spring they close the canopy to capture light, and how long the canopy stays green through July. Imagery for the Field of Wheat was obtained through AgSpace and shows the impact of rabbit grazing in the north of the field.

Satellite imagery from the Field of Wheat

January 15 2015 NDVI

Feb 18 NDVI

Mar 14 NDVI

April 20 NDVI

April 20, Chlorophyll

Ultimately we'd like to be able to provide a dashboard for crops that shows the light available to crops through the season and the amount captured, the water available in the soil, and accumulated temperature which indicates development.

Since we started the YEN in 2012, average UK wheat yields have increased year on year, reaching 8.8 t/ha in 2015 – We'd love to be able to claim some credit, but the favourable weather in 2014 and 2015 was undoubtedly the biggest factor. However, we hope that these recent yields do represent a breakthrough from the yield plateau and that a new positive yield trend is established. The yields from 2016 will indicate the path we are on.

Daniel Kindred, August, 2015