Department for Environment Food & Rural Affairs

ADAS





Integrated Pest Management: Science and Practice
Disease control in cereals

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A video series funded by Defra and produced by ADAS

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How long does the crop canopy need protecting?

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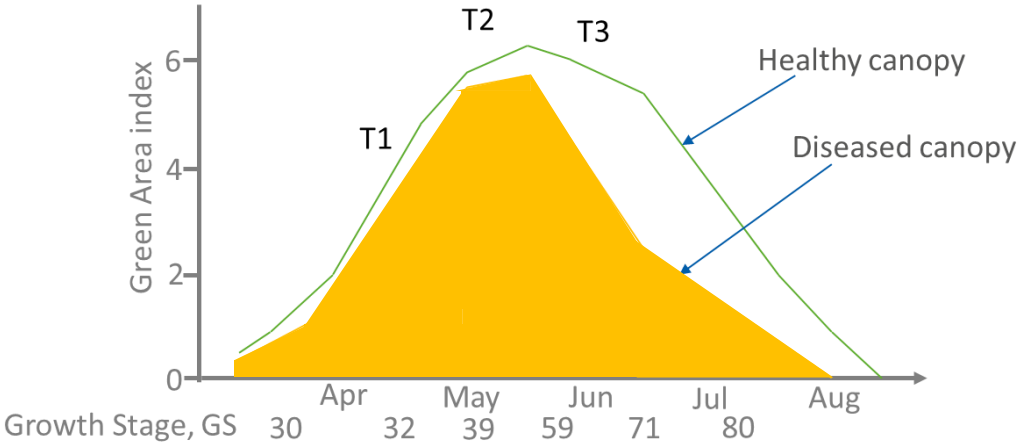
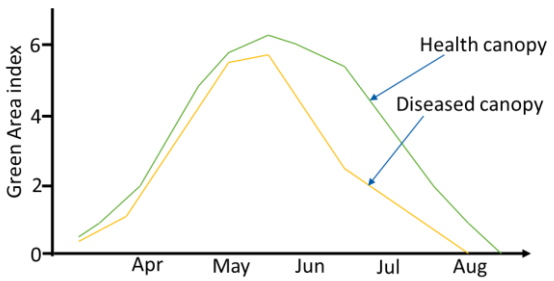
The following slides explore theory and evidence about the effects of green canopy duration

First we need a measure of green (healthy) canopy duration and its effect on light interception

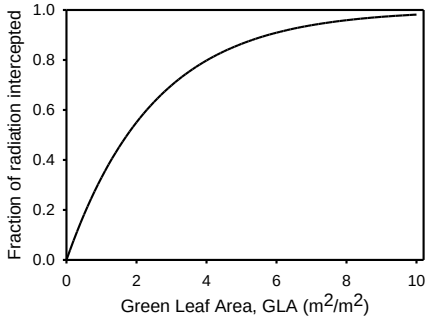


GAI integrated over time = Healthy Area Duration (HAD)

Calculating light interception by the canopy



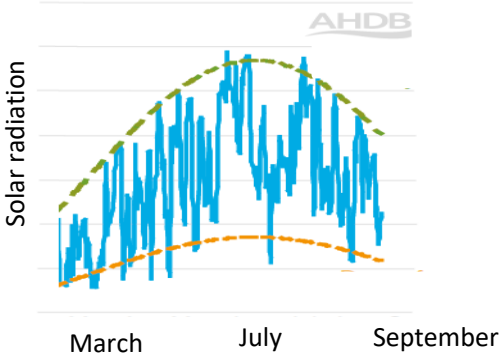
GAI is a function of time, *GAI*(*t*)



Beer's law $f = 1 - e^{-k\,GAI}$

f = fraction of PAR intercepted

k= extinction coefficient

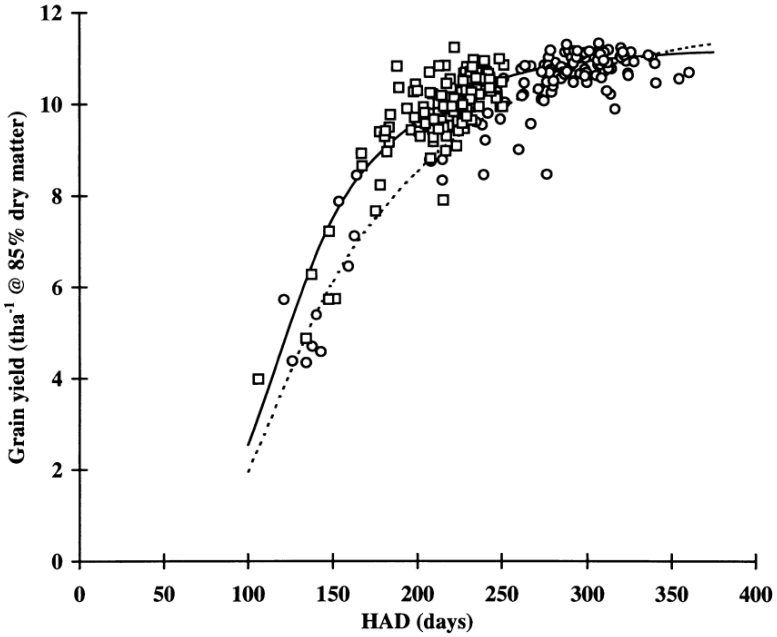


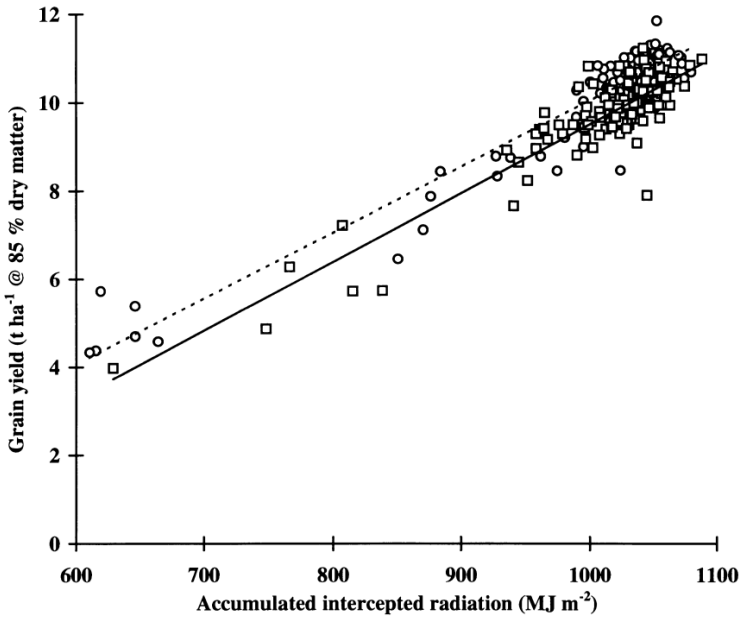
$T(t)$ = Intercepted PAR

$$T(t) = I(t)\left(1 - e^{-k\,GAI(t)}\right)$$

Intercepted PAR, summed over time = Healthy Area Absorption (HAA)

HAD and HAA as predictors of yield - Wheat



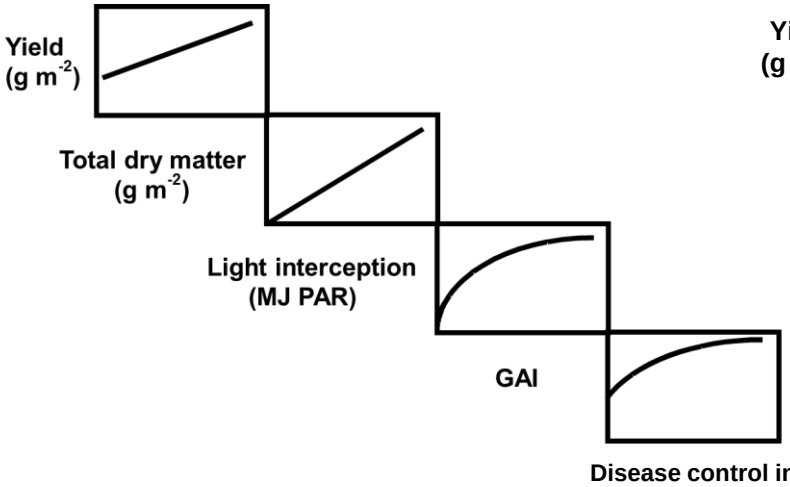


Data from field plots affected by yellow rust. Dotted line (round symbols) and solid line (square symbols) are two years.

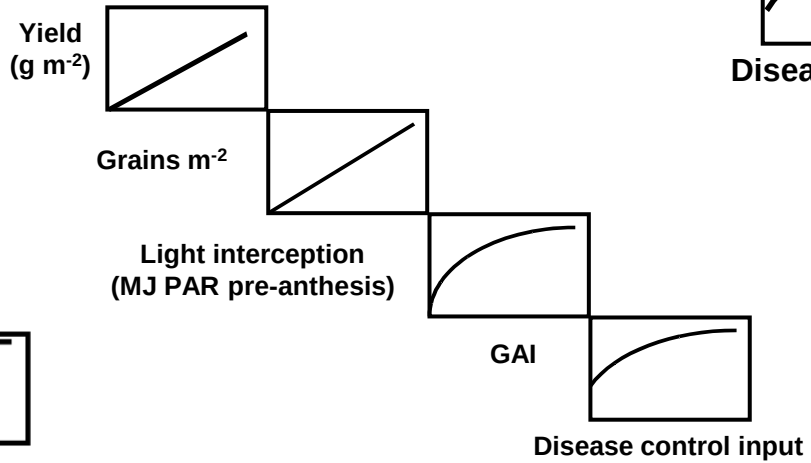
Source: Bryson et al. (1997) European Journal of Plant Pathology

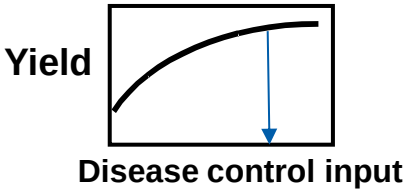
Processes by which disease control increases yield

Wheat



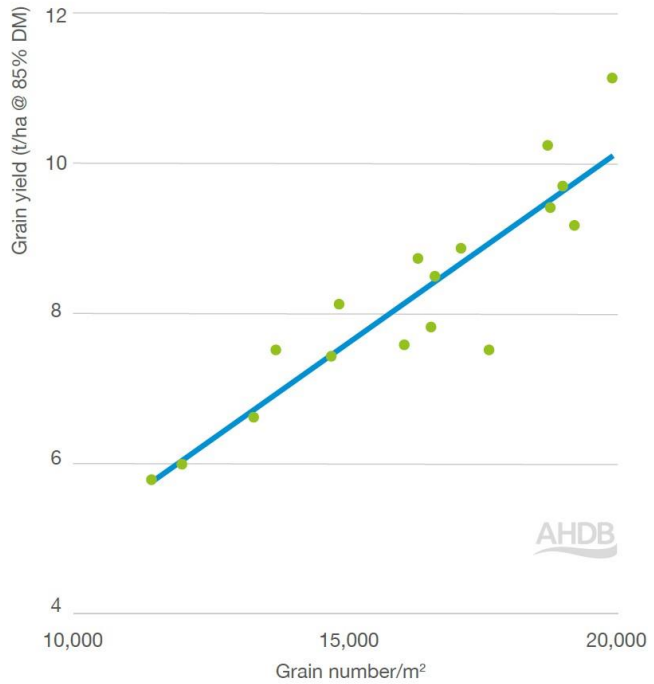
Barley





Source: Paveley et al. (2001) *Phytopathology*

Grain number and grain yield - Barley



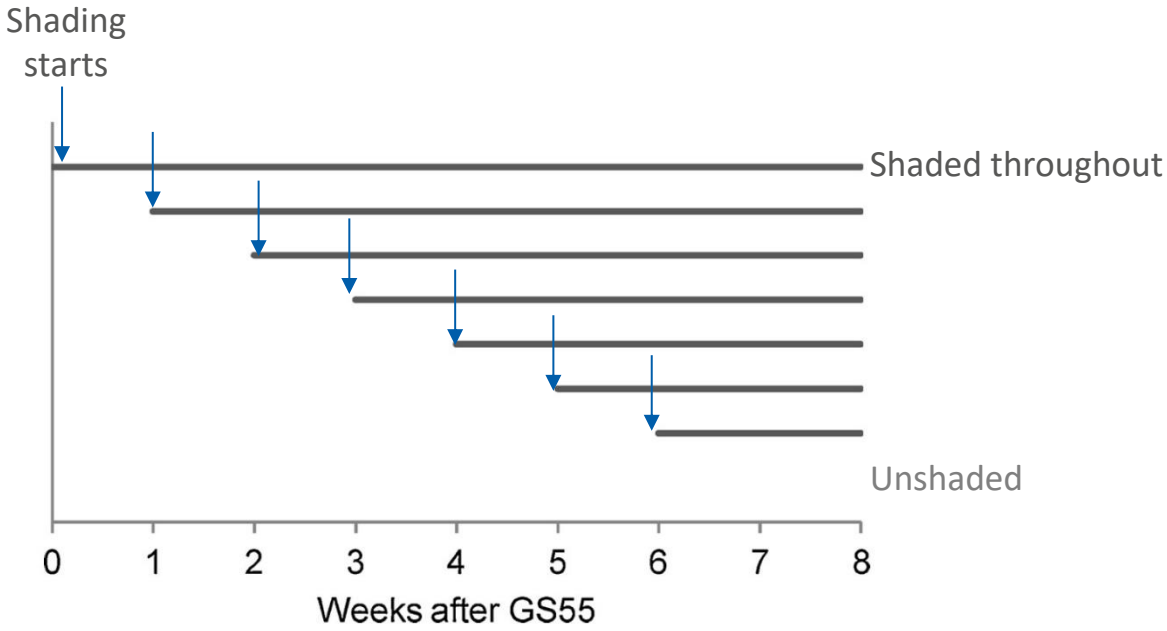
High yields depend on sufficient numbers of ears and fertile spikelets per ear,

The aim is to control disease to maximise growth during tillering and tiller survival and as ears form.

Limited scope for an increase in grains per ear to compensate for low ears per m^2

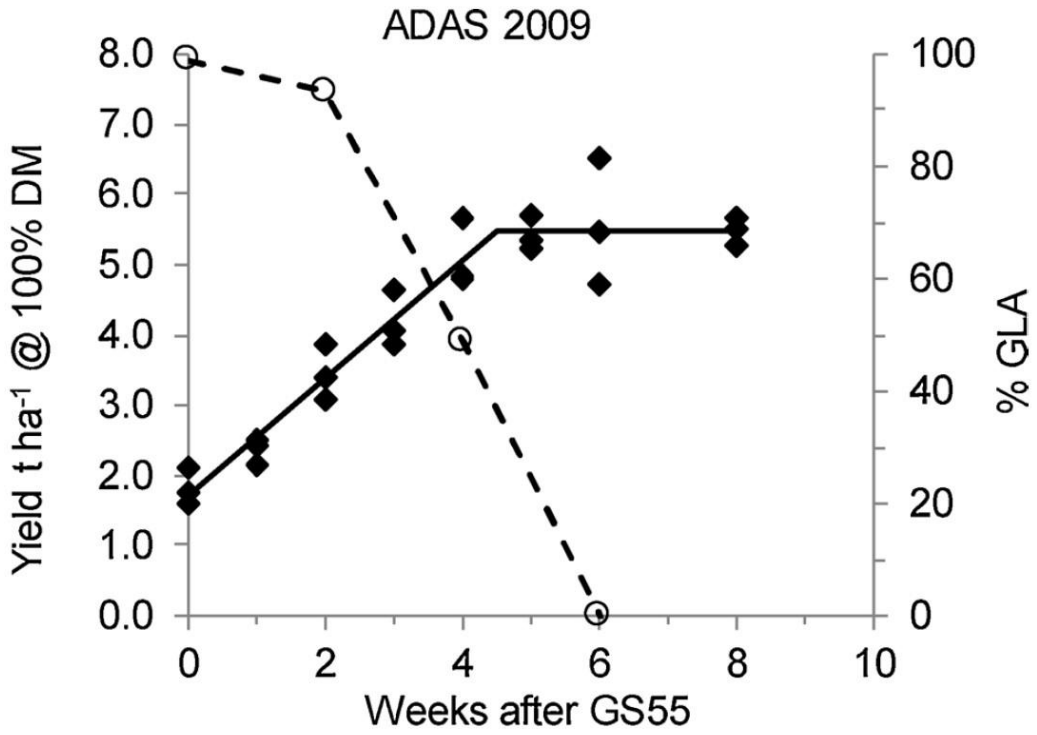
Source: AHDB Barley Growth Guide

When does further HAA stop increasing yield – Barley



Source: Bingham et al. (2019) Field Crops Research

When does further HAA stop increasing yield – Barley



Source: Bingham et al. (2019) Field Crops Research

How long does the crop canopy need protecting?

Canopy size and duration can be measured by healthy area duration (HAD) and absorption (HAA)

HAA relates more consistently to dry matter accumulation than HAD, but is more complicated

Wheat:

- No further grain filling occurs once grain moisture is below 45%, around GS87
- Possible to maintain green canopy beyond that point, without benefit to yield
- However, in general, the higher the HAA, the higher the yield, as wheat usually has sufficient sink capacity to store the extra dry matter
- The economic optimum for canopy size and duration will be below the maximum achievable, due to costs of nutrition and crop protection

Spring barley:

- Critical to maintain green canopy for 3 to 5 weeks after GS 55 (ears half emerged)
- Further increases in HAA may not increase yield as sink capacity has been filled

Further reading and acknowledgements

We acknowledge the help of Ian Bingham (SRUC) in producing this video

Guides

AHDB Wheat growth guide. https://ahdb.org.uk/knowledge-library/wheat-growth-guide

AHDB Barley growth guide. https://ahdb.org.uk/knowledge-library/barley-growth-guide

AHDB Wheat and barley disease management guide. https://ahdb.org.uk/knowledge-library/integrated-pest-management-ipm-of-cereal-diseases

Books

Crop physiology: case histories for major crops. Editors: Sadras VO, Calderini DF (2021). https://doi.org/10.1016/C2018-0-05018-5

Research papers by the authors on the theme of this video. Beed, F D, Paveley, N D, Sylvester-Bradley, R (2007). Predictability of wheat growth and yield in light-limited conditions. *Journal of Agricultural Science* **145**, 63-79

Bingham I J, Young C, Bounds P, Paveley N D (2019). In sink-limited spring barley crops, light interception by green canopy does not need protection against foliar disease for the entire duration of grain filling. Field Crops Research 239:124-134.

Bingham I J, Young C, Bounds P, Gravouil C, Paveley N D (2021). Mechanisms by which fungicides increase grain sink capacity and yield of spring barley when visible disease severity is low or absent. Field Crops Research 261.

Bryson, R J, Paveley, N D, Clark, W S, Sylvester-Bradley, R and Scott, R K (1997). Use of in-field measurements of green leaf area and incident radiation to estimate the effects of yellow rust epidemics on the yield of winter wheat. *European Journal of Agronomy **7**, 53-62.*

Milne, A, Paveley, N D, Audsley, E, Livermore P (2003). A wheat canopy model for use in disease management decision support systems. *Annals of Applied Biology* **143**, 265-274.

Milne, A, Paveley, N, Audsley, E, Parsons, D (2007). A model of the effect of fungicides on disease induced yield loss, for use in wheat disease management decision support systems. *Annals of Applied Biology* **115**, 113-125

Paveley, N D, Sylvester-Bradley, R, Scott, R K, Craigon, J and Day, W (2001). Steps in predicting the relationship of yield on fungicide dose. *Phytopathology* **91**, 708-716.

Many excellent papers are available by other authors. The wheat and barley chapters in the crop physiology book listed above contain comprehensive bibliographies. If a research paper is not open-access you can request a copy by contacting authors through www.researchgate.net