

Studying senescence to increase grain quality in wheat

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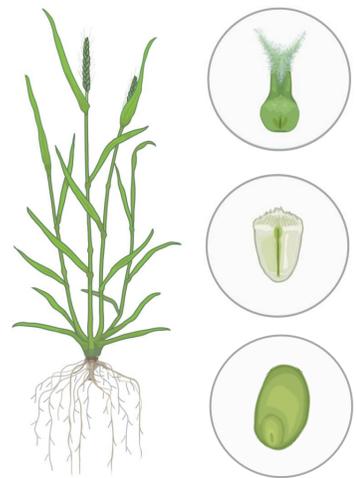
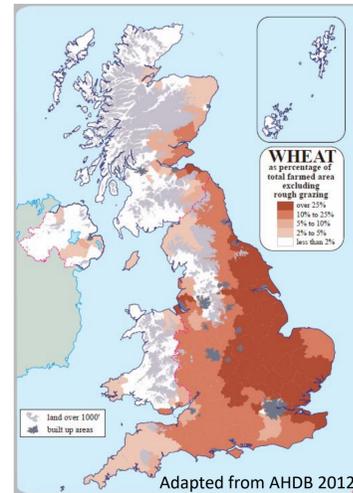
 @sa_harrington



Wheat is the **most important cereal crop in the UK**, covering approximately 1.8 million hectares of land in 2018 [1]. This land is concentrated in the east of England and the midlands, but spreads across nearly the entirety of the UK [2]. An essential part of most diets, wheat provides not only 25% of the daily calories consumed worldwide, but also **20% of the protein** [3].

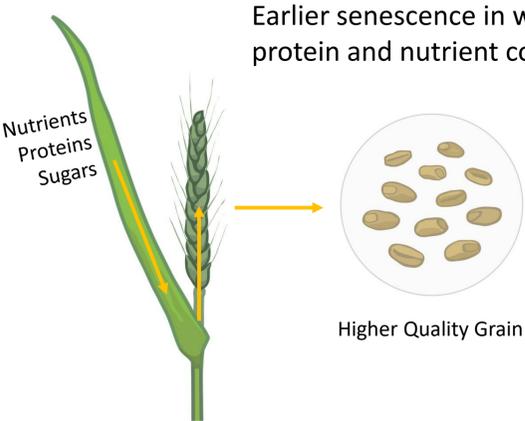
Based on grain protein levels, wheat produced in the UK is classed into four groups which determine which kind of product the grain can be used for. Grains with high levels of protein (at least 13%) are classed as group 1, and can be used for bread flour. These grains are **higher quality**, and fetch a price premium. Grains with lower protein content (less than 11%, group 4) are unsuitable for bread production and are instead typically used as animal feed.

Protein levels in the grain are set during grain development, after self-pollination of the wheat plant. Loading of protein into the grain is tightly coupled to a process called **senescence**. Senescence in wheat occurs after reproduction, as the green, photosynthetic tissues of the plant begin to die.



Why is senescence related to grain quality?

Earlier senescence in wheat is associated with higher protein and nutrient content in the grain.



During senescence, nutrients, proteins, and sugars are remobilised from the leaf tissue into the developing grain.

Understanding how the movement of these molecules is regulated can help us breed for wheat with higher grain quality.

How is senescence regulated in wheat?

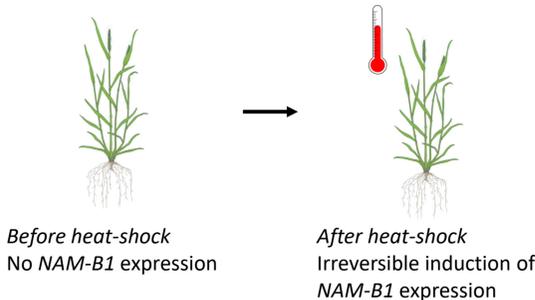
We know that senescence is a very tightly controlled process from studies in other plants like the model organism *Arabidopsis thaliana*.

Only two genes have been found in wheat which regulate senescence. Currently we don't know how the function of these genes affects senescence.

My research has focussed on **identifying new genes** involved in regulating senescence, and **characterising the genes** we already know regulate senescence.

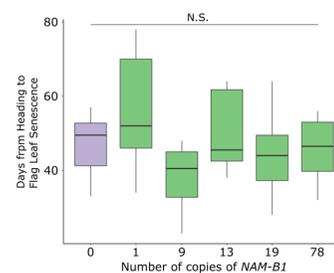


1. A positive regulator of wheat senescence, *NAM-B1*, is necessary but not sufficient for senescence.



One gene, *NAM-B1*, promotes senescence in wheat [4]. We wanted to test whether *NAM-B1* could cause a young plant to die prematurely. To test this, we developed a novel transgenic approach that lets us **turn *NAM-B1* on at any point in development** using a "heat-shock" treatment.

This is important, because if *NAM-B1* can cause the wheat plant to die at any point then if we expressed *NAM-B1* from the seedling stage the plant would die so quickly that we wouldn't be able to study it.



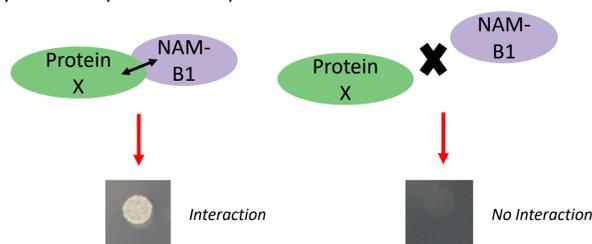
But... we found that **over-expressing *NAM-B1* was not sufficient to kill the plants.**

Plants expressing *NAM-B1* from a young stage (3 leaf; green) showed no significant difference in senescence timing compared to wild-type plants (purple)

This suggests that *NAM-B1* cannot induce senescence on its own, and might require at least one other partner to initiate this process.

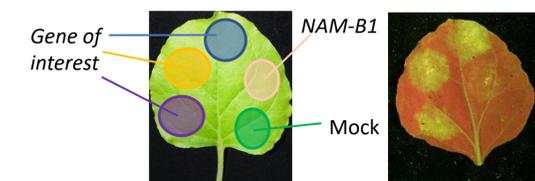
2. A transcription factor interacts with *NAM-B1* and is also a positive regulator of senescence

To figure out which proteins might be interacting with *NAM-B1*, we carried out a Yeast-2-Hybrid screen. This lets us use yeast as a system to test protein interactions.



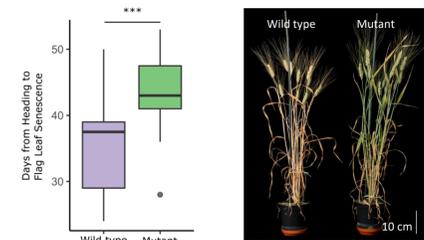
If the proteins interact then the yeast can survive on selective media. We identified one transcription factor from the same family as *NAM-B1* which can interact with *NAM-B1* in yeast.

The next step was to see if the identified protein also regulated senescence. We established a system using a different plant, *N. benthamiana*, in which we can express the gene of interest and see if it causes cell death. This is useful because we think this gene might also be a positive regulator of senescence (like *NAM-B1*).



This experiment showed us that the gene of interest was even better at causing cell death than *NAM-B1*. But what is the gene doing in wheat?

The ultimate test of gene function is to see what happens when the gene is prevented from functioning properly in wheat itself. We used a novel resource to identify specific mutations in the gene of interest that we predicted would stop it from functioning [5].



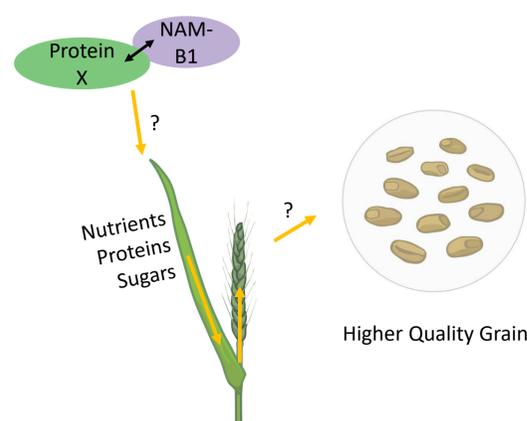
Using these mutations, we found that wheat plants that lack the function of this gene senesce later. This means that this gene acts as a **positive regulator of senescence in wheat.**

What comes next?

We've shown that the wheat gene *NAM-B1* is **needed for senescence, but is not sufficient** to induce senescence alone. Alongside this, we've identified a different gene that is also needed for senescence, and which **interacts with *NAM-B1***.

We're currently testing the relationship between these two genes to see if the interaction between *NAM-B1* and our gene of interest is required for senescence in wheat. We are also investigating what impact our new gene has on grain quality.

With this work we are coming closer to understanding how senescence and grain quality levels are controlled in wheat.



References

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