The Role of Genes in Wheat Growth

The growth characteristics of wheat are, as in all other plants and animals, controlled by the genes within the cells of the plant or animal. Each gene is a series of proteins linked into a chain, with a number of genes being joined into a longer chain to create a chromosome. All the chromosomes in the cell form the genome.

The order of the proteins in each chromosome is unique to the individual chromosome and forms the DNA of the cell, each plant or animal having a different DNA pattern. Plant or animal species that are very closely related will have more of their DNA, and therefore their genes, in common with each other, while those that are unrelated will have DNA that is very different. It has even been estimated that humans and chimpanzees have 95% of their DNA identical.

Wheat has a large genome of 42 chromosomes, created from the three closely related genomes originally derived from the three wild species, an einkorn wheat and two goat grasses. These interbred many thousands of years ago as illustrated in the display on the Evolution of Wheat located on the garner floor of the mill.

Wheat was originally a very tall plant with seed spikes or ears located at the top of the stems. A painting by the Flemish artist Pieter Bruegel the Elder, painted in 1565, shows wheat up to the heads of the men harvesting it with scythes.

In order to increase the yield of the wheat crop, farmers often apply large quantities of fertilisers to the growing crop. However, this can produce tall plants with a lush foliage that are prone to falling over, or ‘lodging’, in very wet or windy conditions. This may cause difficulties when harvesting, either because of the height of the crop or because it has fallen onto the ground.

In the past, especially in remoter parts of the world, wheat was often grown by farmers who saved seed from one year to sow the next year. Over many years, mutations within the genome created many ‘landraces’ of wheat that varied slightly to become specific to particular areas.

Wheat breeders examining wheat from many parts of the world discovered some landraces that, although they only produced a low yield, contained a gene that created a shorter plant. It was discovered later that other similar genes also produced shorter wheat plants so that they became known as reduced-height genes.

When these shorter landraces were hybridised with higher yielding varieties, new varieties of shorter wheat were created. Unfortunately they still produced a reduced yield. Later, by using selective breeding, the 'harvest index', the ratio of grain weight to total plant weight, could be increased. Even when large quantities of fertilisers were applied to increase the yield, the plants remained shorter and had stiffer stems. They were therefore less likely to fall over in wet or windy conditions.

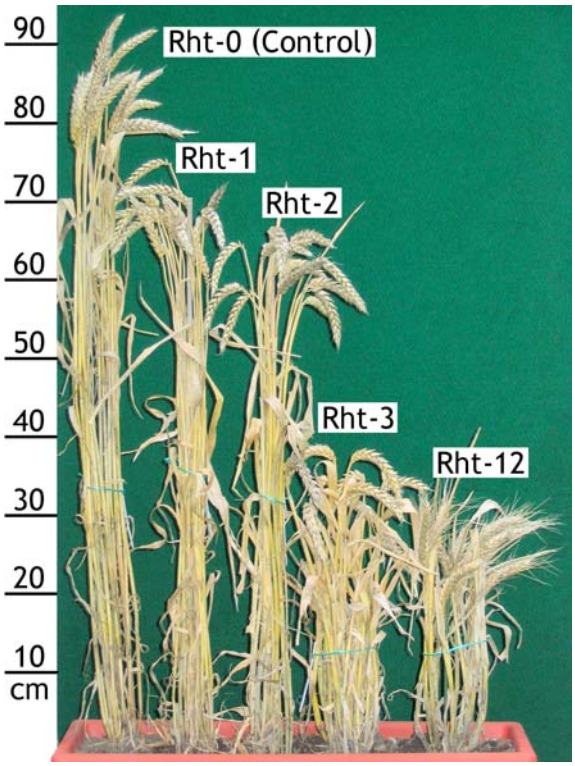
Most modern wheat varieties now include a reduced-height gene within their genome to produce plants that are typically 18 to 24 inches high. The combines used for harvesting wheat are adjusted to cut about four to six inches above the ground to avoid stones, unwanted rubbish and unevenness of the ground. Wheat that is very tall may lead to straw blockages in the combines while very short wheat could result in part of the crop being lost unless it is cut very low, well below the grain ears.

Within the cage, used for protection against predators, are the following demonstration plots:

1. An old Armenian variety that could grow to over five feet high.
2. The 'Mercia' variety without any reduced-height genes used as the control to demonstrate the original height (Rht-0).
3. The 'Mercia' variety with reduced-height gene Rht-1 (Rht-B1b).
4. The 'Mercia' variety with reduced-height gene Rht-2 (Rht-D1b).

The genes Rht-1 and Rht-2 produce semi-dwarf plants about two-thirds of the height of the 'Mercia' variety control. The genes were originally discovered in Japanese landraces and then transferred into many other varieties to produce shorter plants

5. The 'Mercia' variety with reduced-height gene Rht-3 (Rht-B1c).
6. The 'Mercia' variety with reduced-height gene Rht-10 (Rht-D1c).
7. The 'Mercia' variety with reduced-height gene Rht-12.



Sample plants grown in 2009
(Rht-10 was not available)
Height scale in cm.

These three genes produce dwarf plants about one-third the height of the control. Rht-12 is a strong height reducing gene that can produce plants less than 12 inches high but, unlike the plants in the other plots, the ears always have awns or bristles. Wheat breeders have been unable to separate the awn gene from the reduced-height gene as the two genes are believed to occur very close together on the same chromosome.