# Barley takes a leaf out of reindeer's book in the land of the midnight sun

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This is Barley. Credit: John Innes Centre

Barley grown in Scandinavian countries is adapted in a similar way to reindeer to cope with the extremes of day length at high latitudes. Researchers have found a genetic mutation in some Scandinavian barley varieties that disrupts the circadian clock that barley from southern regions use to time their growing season. Just as reindeer have dropped the clock in adapting to extremely long days, so has Scandinavian barley to grow successfully in that region's short growing season. This new knowledge may be useful in efforts to adapt crops for regions where the growing season is short.

The timing of when a plant flowers during the year is crucial to its overall survival and fitness, and in crop plants it has major affects on the overall yield. Barley's wild ancestors and modern winter barley varieties germinate in the autumn, but don't flower until after winter has finished. One stimulus that triggers flowering is the longer days that come with spring.

To know how long the day is, the plant uses its built in circadian clock, with which they time a 24 hour period. Circadian clocks are found throughout the plant and animal kingdom, and affect all manner of processes such as when animals eat and sleep, or when plants photosynthesise. As anyone who has suffered jet lag knows, anything that disrupts the circadian clock of an organism causes big problems, which is why when researchers from the John Innes Centre and the Max Planck Institute sought to characterise Scandinavian barley varieties, they were surprised to find a mutant gene that knocked out the circadian clock and its functions.

The research, published in the Proceedings of the National Academy of Sciences, shows that by disrupting the circadian clock Scandinavian barley varieties flower independently of the length of the day. This means that they flower much earlier than their southern counterparts and so can fit their growth cycle into the shorter growing season.

Our knowledge of plant development and genetics would suggest that there are ways of encouraging early flowering without affecting the circadian clock, so why was a clock mutant selected?

In the UK and much of Western Europe cold winters and warm wet summers favoured the development of barleys which didn't need the period of overwintering and could be planted in the spring. A late flowering mutation in another gene called Photoperiod-1 allowed barley to be planted in the spring and use the long days of summer to build up its yield, without its growing season being shortened by the high temperatures experienced by its ancestors from the south. This gene was also identified at the John Innes Centre, which is strategically funded by the Biotechnology and Biological Sciences Research Council.

As barley cultivation moved north this late flowering background became unsuitable for the short growing season in Scandinavia as the plants couldn't achieve good yields before temperatures plunged. This was overcome by introducing a second mutation that removes the influence of the circadian clock, making the barley plants insensitive to day length and allowing earlier flowering.

Alternatively, the mutation may combine early flowering with additional useful side effects such as turning off the circadian control of photosynthesis. This could help Scandinavian barley exploit the 20 hours of sunlight during the day. This physiological explanation has an intriguing parallel in animals. Reindeer have similarly evolved to switch off their circadian clock, abandoning the more regimented lifestyle of their antelope ancestors to be able to display more opportunistic behaviour.

Plant breeders and scientists now have the tools and knowledge of genetics to rationally design crops to be best adapted to specific regions, and this study adds to the growing wealth of genetic data on cereal crops. Whilst the mutation identified here would be useless for UK barleys that benefit from late flowering, it could be very useful for breeding varieties to take advantage of new environments or changing climate. Crops have a wide distribution all over the world, representing a rich source of genetic variation and adaptation, which modern plant science is now exploring to help develop better crops and protect food security.

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