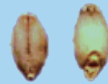


## A New Mechanism to Control Seed Dormancy in Barley



**Kazuhiro Sato** Professor  
Barley and Wild Plant Resource Center,  
Institute of Plant Science and Resources,  
Okayama University

A paper on the gene governing seed dormancy in barley was published in the *Nature Communications* issue of May 18, 2016. Wild barley, which is the ancestor of currently cultivated barley, grows wild mainly in the Middle East. Wild barley grows from autumn to spring. After ripening, it ceases germination for a certain period of time and diapauses in the seed stage for several months to withstand the high temperatures and dryness of summer. Cultivation-type barley was derived from wild barley approximately ten thousand years ago and distributed to various parts of the world.



The international joint research group analyzed the DNA sequences of barley varieties in which the duration of seed dormancy was different for each variety and found that when one amino acid in the protein encoded by the gene controlling seed dormancy changed, the gene changed from being the dormant type to the non-dormant type (Photo. 1).



Photo. 1. Germination of barley strains five weeks after seed dormancy termination in which only the gene governing seed dormancy differed in each strain: (left) dormant type and (right) non-dormant type

Studies have been conducted for around 50 years in Okayama University about seed dormancy in barley; the degree of seed dormancy of approximately 5,000 cultivated and wild barley varieties throughout the world have been investigated and the findings have confirmed that the duration of seed dormancy of a certain wild barley species is longer than that of other species. It has also been revealed that the duration of seed dormancy differs greatly according to the region or use of cultivated barley. Subsequently, a genetic analysis revealed that many genes were involved in seed dormancy. However, the structures and functions of these genes remained unknown.

The international joint research group also found that *Qsd1*, the gene governing seed dormancy, controlled alanine aminotransferase, which was earlier not considered to be involved in the dormancy of plant seeds. Previously, plant hormones such as abscisic acid (ABA) were considered to be involved in the dormancy of plant seeds. However, the gene governing seed dormancy in barley, which was analyzed in this research, was revealed to be controlled by a cause that was not directly related to the action of plant hormones.

the same part of the DNA sequence changed, the amino acid changed, and the protein changed; consequently, the changed protein facilitated germination. Many of these varieties with short durations of seed dormancy are used for brewing. The DNA sequencing revealed that these varieties were derived from wild barley that grew in Israel (the South Levant: Fig. 1). The wild barley that originated from Israel then spread to Europe as cultivated barley. When the cultivated barley was improved to be used for brewing mainly in the Czech and Britain, its duration of seed dormancy was shortened. The cultivated barley with its short duration of seed dormancy was then spread to all parts of the world, including Japan, during modern times.



Fig. 1. The shaded region is known as the Levant

### Identification and function of the gene governing seed dormancy

Recently, the international joint research group consisting mainly of Okayama University and the National Agriculture and Food Research Organization determined the DNA sequence of *Qsd1*, a major gene that governs seed dormancy in wild barley, using the latest advances in science and technology wherein genome information, genetic analysis, and molecular biology techniques were combined.

### The gene governing seed dormancy works only in the embryo

Five genes (including *Qsd1*) were reported to encode alanine aminotransferase. This enzyme interconverts pyruvic acid and glutamic acid with alanine and alpha ketoglutaric acid and works through all the growing periods of seeds, leaves, roots, etc.

However, unlike other alanine aminotransferase-encoding genes in barley, *Qsd1*, which was analyzed in the present study, was revealed to act specifically in the embryo in the seed as the seed ripens (Photo. 2).

### The duration of seed dormancy was shortened due to brewing

When the DNA sequences of *Qsd1* from more than 300 wild and cultivated barley varieties collected from all over the world were compared, it was revealed that in certain varieties where the durations of seed dormancy were shortened,

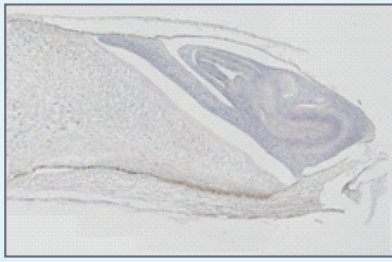


Photo. 2. A seed of wild barley on the 19th day after fertilization. In the upper right part of this photograph, the gene governing seed dormancy stained by the molecular cross acts in the embryo.

It was also found that barley has a mechanism that controls alanine metabolism and adjusts the duration of seed dormancy by making this gene act specifically in the embryo of the seed (Fig. 2).

Genes to encode alanine aminotransferase also exist in other plants. In particular, some genes in rice act in the embryo of the seed, similar to the *Qsd1* gene in barley. However, no alanine aminotransferase-encoding gene was reported to act on seed dormancy.

The duration of seed dormancy differs according to the variety of cultivated barley and the difference in the duration of seed dormancy is attributed to the difference in the DNA sequence.

The duration of seed dormancy in barley that is used to make malt for beer and whisky must be short and the barley must germinate uniformly and simultaneously. In areas where rainfall is frequent during the harvest season of barley, such as in Japan and North Europe, pre-harvest sprouting, in which seeds germinate before the ears drop, causes a serious problem. The results obtained in the present study are expected to contribute to the brewing industry and the production of barley by controlling the duration of seed dormancy, which can be examined by genetic testing, in areas where rainfall occurs during the harvest season.

Reference :

Sato K, Yamane M, Yamaji N, Kanamori H, Tagiri A, Schwerdt J, Fincher G, Tatsumoto T, Takeda K and Komatsuda T. Alanine aminotransferase controls seed dormancy in barley (2016) *Nature Communications* DOI:10.1038/NCOMMS11625

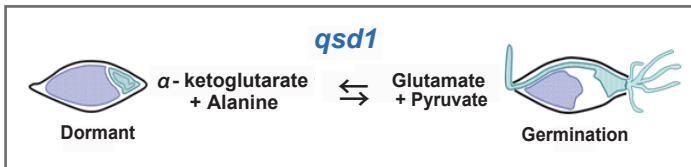


Fig. 2. A mechanism in which *Qsd1* controls alanine metabolism and adjusts the duration of seed dormancy

Searching Google Scholar using your Mac's Services Function

For those academics who use Mac computers, I introduced an application that is installed by default in Mac OS X, called Automator, in the May 2014 issue of our newsletter (Vol. 10, No. 5). In that article, I explained using Automator to rename files and add sequential numbers to file names in a batch. In this article, I would like to introduce a way for searching articles in Google Scholar by using a workflow created with Automator.

Preparation

- Go to <http://schutt.org/blog/2009/11/services-menu/> and click on the link titled "Search with Google Scholar" located at the bottom of the page to download the workflow file (Fig. 1).

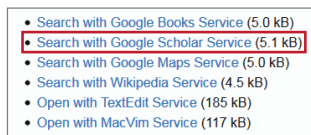


Fig. 1. Downloading the workflow file

- Click on the "Go" menu from Finder, press [option] key while the menu is still being displayed, and the "Library" menu item will appear. Select this menu (Fig. 2A) to go to the Library folder. Next, copy the "Google Scholar.workflow" file that you have just downloaded folder into the "Services" folder inside the "Library" folder (Fig. 2B). This ends the preparation step.

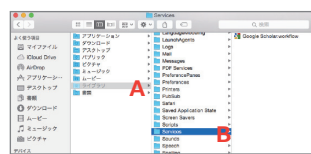


Fig. 2. Where to save the workflow file

Searching

Normally, you would search for articles by entering keywords in the Google Scholar website. This workflow functions as a Service in Mac OS X, so you can search straight from text files, PDF files, a webpage opened in a web browser, or other places where you can select text, and the results will be shown on the Google Scholar website.

Contact Address

Genetic Resource Center, National Institute of Genetics  
1111 Yata, Mishima-shi, Shizuoka 411-8540, Japan  
Tel.: 055-981-6885 (Yamazaki)  
E-mail : brnews@shigen.info

BioResource Information

(NBRP) [www.nbrp.jp/](http://www.nbrp.jp/)  
(SHIGEN) [www.shigen.nig.ac.jp/](http://www.shigen.nig.ac.jp/)  
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(JGR) [www.shigen.nig.ac.jp/wgr/jgr/jgrUrlList.jsp](http://www.shigen.nig.ac.jp/wgr/jgr/jgrUrlList.jsp)

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Fig. 3 illustrates an example where the botanical name of a cedar is selected in an article from the January 2016 issue of the BioResource Now! newsletter (PDF file) and the selected text is used to search using the workflow. By right-clicking on the keyword and selecting "Search with Google Scholar" from the context menu, the browser opens to show search results within Google Scholar (Fig. 4).

Fig. 3. Sample search menu

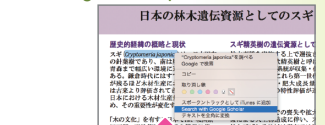


Fig. 4. Search results in Google Scholar



In cases where the right-click context menu does not show the "Search with Google Scholar" menu item, such as when a PDF file is displayed within a browser, you can always click on the application menu ("Safari" in the example below) and select the "Services" sub-menu (Fig. 5C).

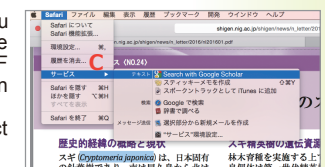


Fig. 5. The "Search with Google Scholar" submenu in the Services menu

Regarding the Workflow

This workflow is made up of two lines of Perl script that insert highlighted text to the Google Scholar URL and an action to open that URL in a browser.

The article where the workflow file was downloaded is old, having been published in 2009; however, a simple workflow such as this one works even with the latest version of OS X, El Capitan.

With this workflow, you can search for multiple keywords that are included in the selected text range, but you cannot add keywords outside of the selected range.

To narrow your search result, you will need to do this after Google Scholar website opens. Nonetheless, as this workflow enables you to search quickly from an article you are reading, it offers a quick shortcut to opening Google Scholar.

(Masakazu Saga)

Editor's Note

I am glad to announce the second splendid achievement in barley research following Btr, a gene that encodes grain shedding, which was published in Cell last year (Btr was also introduced in BioResource Now! Vol. 11 No. 11). The discovery of the gene governing seed dormancy published in Nature this time is a promising result obtained using the abundant genetic resources of Okayama University and the latest science and technology. Such research needs to be pursued in all earnestness and positivity than ever before. When having a glass of beer or whisky, one would do well to remember the long history of barley breeding and its molecular mechanism, because the season for drinking has just arrived (Y. Y.).