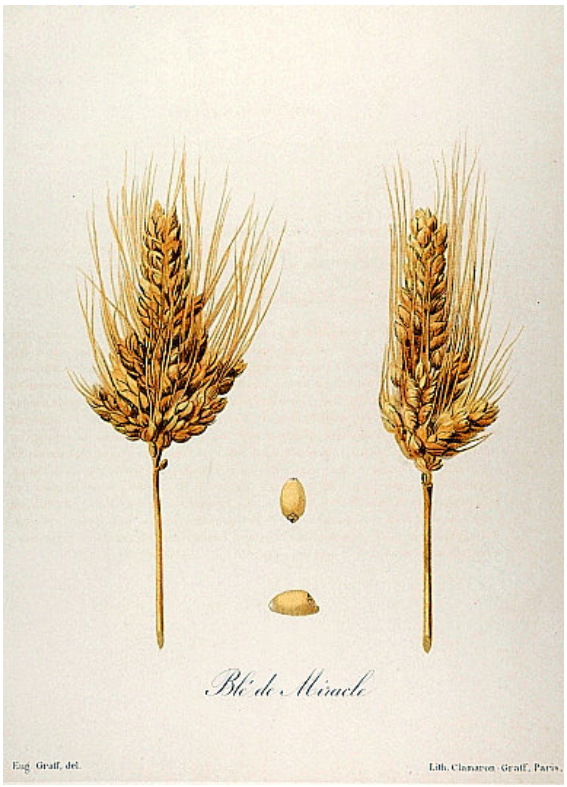
Taxonomy of wheat



*Miracle wheat (*Triticum turgidum *var.* mirabile*).*

During 10,000 years of cultivation, numerous forms of wheat have evolved under human selection. This diversity has led to much confusion in the naming of wheats. This article explains how genetic and morphological characteristics of wheat influence its classification, and gives the most common botanical names of wheat in current use (see Table of wheat species). Information on the cultivation and uses of wheat is at the main wheat page.

1 *Aegilops* and *Triticum*

The genus *Triticum* includes the wild and domesticated species usually thought of as wheat.

In the 1950s growing awareness of the genetic similarity of the wild goatgrasses (*Aegilops*) led some botanists to amalgamate *Aegilops* and *Triticum* as one genus, *Triticum*. This approach is still followed by some (mainly geneticists), but has not been widely adopted by taxonomists. *Aegilops* is morphologically highly distinct from *Triticum*, with rounded glumes rather than keeled glumes.

Spike and spikelets of Aegilops tauschii

Aegilops is important in wheat evolution because of its role in two important hybridisation events. Wild emmer (*T. dicoccoides* and *T. araraticum*) resulted from the hybridisation of a wild wheat, *T. urartu*, and an as yet unidentified goatgrass, probably similar to *Ae. speltoides*. Hexaploid wheats (e.g. *T. aestivum* and *T. spelta*) are the result of a hybridisation between a domesticated tetraploid wheat, probably *T. dicoccum* or *T. durum*, and another goatgrass, *Ae. tauschii* (also known as *Ae. squarrosa*).

2 Early taxonomy

Botanists of the classical period, such as Columella, and in sixteenth and seventeenth century herbals, di-

vided wheats into two groups, *Triticum* corresponding to free-threshing wheats, and *Zea* corresponding to hulled ('spelt') wheats.

Carl Linnaeus recognised five species, all domesticated:

- *T. aestivum* Bearded spring wheat
- *T. hybernum* Beardless winter wheat
- *T. turgidum* Rivet wheat
- *T. spelta* Spelt wheat
- *T. monococcum* Einkorn wheat

Later classifications added to the number of species described, but continued to give species status to relatively minor variants, such as winter **vs.** spring forms. The wild wheats were not described until the mid-19th century because of the poor state of botanical exploration in the Near East, where they grow.

The development of a modern classification depended on the discovery, in the 1920s, that wheat was divided into 3 ploidy levels.

3 Important characters in wheat

3.1 Ploidy level

As with many grasses, polyploidy is common in wheat. Some wheats are not polyploid. There are two wild diploid wheats, *T. boeoticum* and *T. urartu*. *T. boeoticum* is the wild ancestor of domesticated einkorn, *T. monococcum*. Cells of the diploid wheats each contain 2 complements of 7 chromosomes, one from the mother and one from the father (2n=2x=14, where 2n is the number of chromosomes in each somatic cell, and x is the basic chromosome number).

The polyploid wheats are tetraploid (4 sets of chromosomes, 2n=4x=28), or hexaploid (6 sets of chromosomes, 2n=6x=42). The tetraploid wild wheats are wild emmer, *T. dicoccoides*, and *T.araraticum*. Wild emmer is the ancestor of all the domesticated tetraploid wheats, with one exception: *T. araraticum* is the wild ancestor of *T. timopheevi*.

There are no wild hexaploid wheats, although feral forms of common wheat are sometimes found. Hexaploid wheats developed under domestication. Genetic analysis has shown that the original hexaploid wheats were the result of a cross between a tetraploid domesticated wheat, such as *T. dicoccum* or *T. durum*, and a wild goatgrass, *Ae. tauschii*.

Polyploidy is important to wheat classification for three reasons:

- Wheats within one ploidy level will be more closely related to each other.
- Ploidy level influences some plant characteristics. For example, higher levels of ploidy tend to be linked to larger cell size.
- Polyploidy brings new genomes into a species. For example, *Aegilops tauschii* brought the D genome into hexaploid wheats, with enhanced cold-hardiness and some distinctive morphological features.

3.2 Genome

Observation of chromosome behaviour during meiosis, and the results of hybridisation experiments, have shown that grass genomes (complete complements of genetic matter) can be grouped into distinctive types. Each type has been given a name, e.g. B or D. Grasses sharing the same genome will be more-or-less interfertile, and might be treated by botanists as one species. Identification of genome types is obviously a valuable tool in investigating hybridisation. For example, if two diploid plants hybridise to form a new polyploid form (an allopolyploid), the two original genomes will be present in the new form. Many thousands of years after the original hybridisation event, identification of the component genomes will allow identification of the original parent species.

In *Triticum*, five genomes, all originally found in diploid species, have been identified:

- A^m - present in wild einkorn (*T. boeoticum*).
- A^u - present in *T. urartu* (closely related to *T. boeoticum* but not interfertile).
- B - present in most tetraploid wheats. Source not identified, but similar to *Ae. speltoides*.
- G - present in *timopheevi* group of wheats. Source not identified, but similar to *Ae. speltoides*.
- D - present in *Ae. squarrosa*, and thus in all hexaploid wheats.

The genetic approach to wheat taxonomy (see below)takes the genome composition as defining each species. As there are five known combinations in *Triticum* this translates into five *super* species:

- A^m *T. monococcum*
- A^u *T. urartu*
- BA^u *T. turgidum*
- GA^m *T. timopheevi*
- BA^uD, *T. aestivum*

3.3 Domestication

There are four wild species, all growing in rocky habitats in the fertile crescent of the Near East. All the other species are domesticated. Although relatively few genes control domestication, and wild and domesticated forms are interfertile, wild and domesticated wheats occupy entirely separate habitats. Traditional classification gives more weight to domesticated status.

3.4 Hulled *vs.* Free-threshing

Left: Hulled wheat (einkorn), with spikelets. Right: Free-threshing wheat (common wheat).

All wild wheats are hulled: they have tough glumes (husks) that tightly enclose the grains. Each *package* of glumes, lemma and palaea, and grain(s) is known as a spikelet. At maturity the rachis (central stalk of the cereal ear) disarticulates, allowing the spikelets to disperse.

The first domesticated wheats, einkorn and emmer, were hulled like their wild ancestors, but with rachises that (while not entirely tough) did not disarticulate at maturity. During the Pre-Pottery Neolithic B period, at about 8000 BC, free-threshing forms of wheat evolved, with light glumes and fully tough rachis.

Hulled or free-threshing status is important in traditional classification because the different forms are usually grown separately, and have very different post-harvesting processing. Hulled wheats need substantial extra pounding or milling to remove the tough glumes.

For more information, see Wheat: Hulled vs. free-threshing wheat

3.5 Morphology

In addition to hulled/free-threshing status, other morphological criteria, e.g. spike laxness or glume wingedness, are important in defining wheat forms. Some of these are covered in the individual species accounts linked from this page, but Floras must be consulted for full descriptions and identification keys.

4 Traditional *vs.* genetic classifications

Although the range of recognised types of wheat has been reasonably stable since the 1930s, there are now sharply differing views as to whether these should be recognised at species level (traditional approach) or at subspecific level (genetic approach). The first advocate of the genetic approach was Bowden, in a 1959 classification (now historic rather than current). He, and subsequent proponents (usually geneticists), argued that forms that were interfertile should be treated as one species (the biological species concept). Thus emmer and hard wheat should both be treated as subspecies (or at other infraspecific ranks) of a single tetraploid species defined by the genome BA^u. Van Slageren's 1994 classification is probably the most widely used genetic-based classification at present.

Users of traditional classifications give more weight to the separate habitats of the traditional species, which means that species that could hybridise do not, and to morphological characters. There are also pragmatic arguments for this type of classification: it means that most species can be described in Latin binomials, e.g. *Triticum aestivum*, rather than the trinomials necessary in the genetic system, e.g. *Triticum aestivum* subsp. *aestivum*. Both approaches are widely used.

5 Infraspecific classification

In the nineteenth century, elaborate schemes of classification were developed in which wheat ears were classified to botanical variety on the basis of morphological criteria such as glume hairiness and colour or grain colour. These variety names are now largely abandoned, but are still sometimes used for distinctive types of wheat such as miracle wheat, a form of *T. turgidum* with branched ears, known as *T. turgidum* L. var. *mirabile* Körn.

The term *cultivar* (abbreviated as *cv.*) is often confused with *species* or *domesticate*. In fact, it has a precise meaning in botany: it is the term for a distinct population of a crop, usually commercial and resulting from deliberate plant-breeding. Cultivar names are always capitalised, often placed between apostrophes, and not italicised. An example of a cultivar name is *T. aestivum* cv. 'Pioneer 2163'. A cultivar is often referred to by farmers as a variety, but this is best avoided in print, because of the risk of confusion with botanical varieties.

6 Advice for users

Anyone wishing to use a botanical name for wheat is best advised to follow an existing classification, such as those listed as *current* at the Wheat Classification

Tables Site. The classifications given in the following table are among those suitable for use. If a genetic classification is favoured, the GRIN classification is comprehensive, based on van Slageren's work but with some extra taxa recognised. If the traditional classification is favoured, Dorofeev's work is a comprehensive scheme that meshes well with other less complete treatments.Wikipedia's wheat pages generally follow a version of the Dorofeev scheme - see the taxobox on the Wheat page.

The most critical point is that **different taxonomic schemes should not be mixed in one context**. In a given article, book or web page, only one scheme should be used at a time. Otherwise, it will be unclear to others how the botanical name is being used.

7 Table of wheat species

Note: Blank common name indicates that no common name is in use in the English language.

7.1 Explanatory notes on selected names

- *Triticum boeoticum* Boiss. is sometimes divided into two subspecies:
  - *T. boeoticum* Boiss. subsp. *thaoudar* (Reut. ex Hausskn.) E. Schiem. - with two grains in each spikelet, distributed to east of fertile crescent.
  - *T. boeoticum* Boiss. subsp. *boeoticum* - one grain in each spikelet, in Balkans.
- *Triticum dicoccum* Schrank ex Schübler is also known as *Triticum dicoccon* Schrank.
- *Triticum aethiopicum* Jakubz. is a variant form of *T. durum* found in Ethiopia. It is not usually regarded as a separate species.
- *Triticum karamyschevii* Nevsky was previously known as *Triticum paleocolchicum* A. M. Menabde.

8 Artificial species and mutants

Russian botanists have given botanical names to hybrids developed during genetical experiments. As these only occur in the laboratory environment, it is questionable whether botanical names (rather than lab. numbers) are justified. Botanical names have also been given to rare mutant forms. Examples include:

- *Triticum* × *borisovii* Zhebrak - (*T. aestivum* × *T. timopheevi*)
- *Triticum* × *fungicidum* Zhuk. - Hexaploid, artificial cross (*T. carthlicum* × *T. timopheevi*)
- *Triticum jakubzineri* Udaczin & Schachm.
- *Triticum militinae* Zhuk. & Migush. - mutant form of *T. timopheevi*.
- *Triticum petropavlovskyi* Udaczin & Migush.
- *Triticum sinskajae* A.A.Filatenko & U.K.Kurkiev - mutant, free-threshing form of *T. monococcum*.
- *Triticum* × *timococcum* Kostov
- *Triticum timonovum* Heslot - Hexaploid, artificial cross.
- *Triticum zhukovskyi* Menabde & Ericzjan (*T. timopheevi* × *T. monococcum*)

9 See also

- Winter wheat vs. spring wheat
- Cultivated plant taxonomy
- List of Canadian Heritage Wheat Varieties

10 References

- Caligari, P.D.S. and P.E. Brandham (eds) (2001). *Wheat taxonomy: the legacy of John Percival* (Linnean Special Issue 3 ed.). London: Linnean Society. p. 190.
- Percival, John (1921). *The wheat plant: a monograph*. London: Duckworth.
- Padulosi, Stefano, Karl Hammer and J. Heller (1996). *Hulled Wheats. Promoting the conservation and use of underutilized and neglected crops. 4. Proceedings of the First International Workshop on Hulled Wheats 21 July 1995 – 22 July 1995, Castelvecchio Pascoli, Tuscany, Italy*. ISBN 92-9043-288-8.
- "Wheat Classification Tables Site". Retrieved January 15, 2006. Lists of *Triticum* names. An essential tool.
- "GRIN taxonomy: *Triticum*". Retrieved January 15, 2006. Includes links to USDA germplasm collection, and public domain images Germplasm Resources Information Network (GRIN)
- "Genomes in Aegilops, Triticum, and Amblyopyrum". *International Triticeae Consortium*. Retrieved January 16, 2006.
- "Triticum taxonomy". *Mansfeld's World Database of Agricultural and Horticultural Crops*. Retrieved January 16, 2006.

11 External links

11.1 Taxonomy

- Les meilleurs blés (1880 and 1909) Also on Pl@ntUse. Beautifully illustrated French book on wheats then in cultivation and studied by the French breeders family Vilmorin.

11.2 Genetics

- International Triticeae Consortium Mainly concerned with the International Triticeae Meeting. Site includes genome tables for Triticeae.
- GrainGenes: Triticeae Taxonomy
- Annual Wheat Newsletter

11.3 Morphology

- Wheat: the big picture Illustrated guide to life cycle of wheat plant

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