Plant Science into Practice

Engineering starch granules in wheat.

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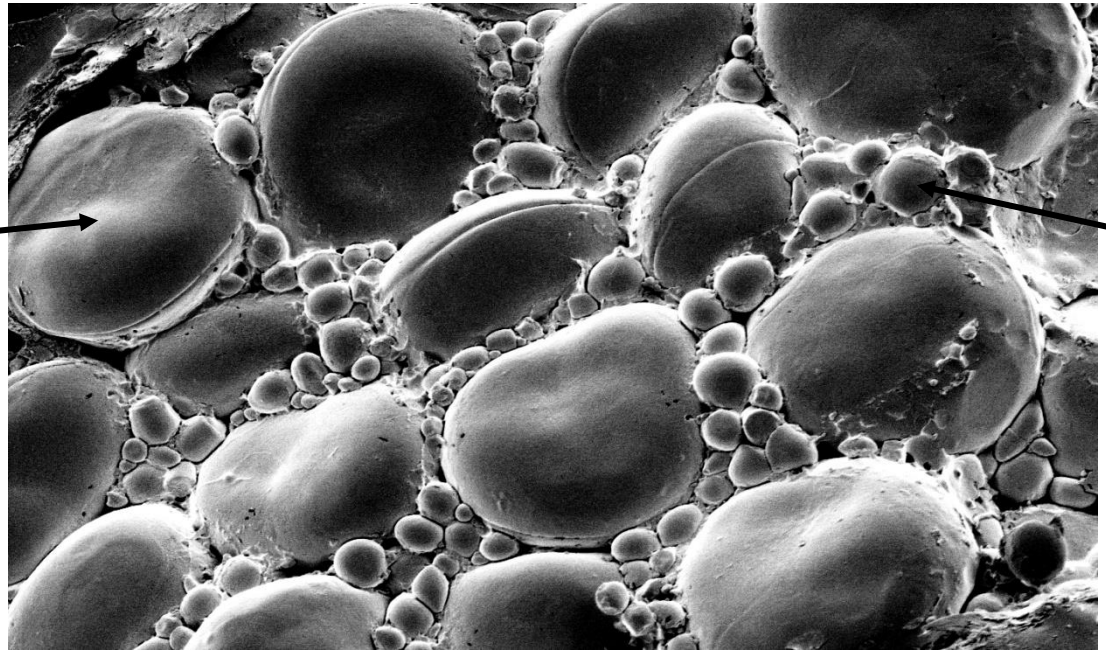
CIRC • CROP IMPROVEMENT RESEARCH CLUB

John Innes Centre

Wheat grain has two types of starch granule.

A-type

Large disc-shaped

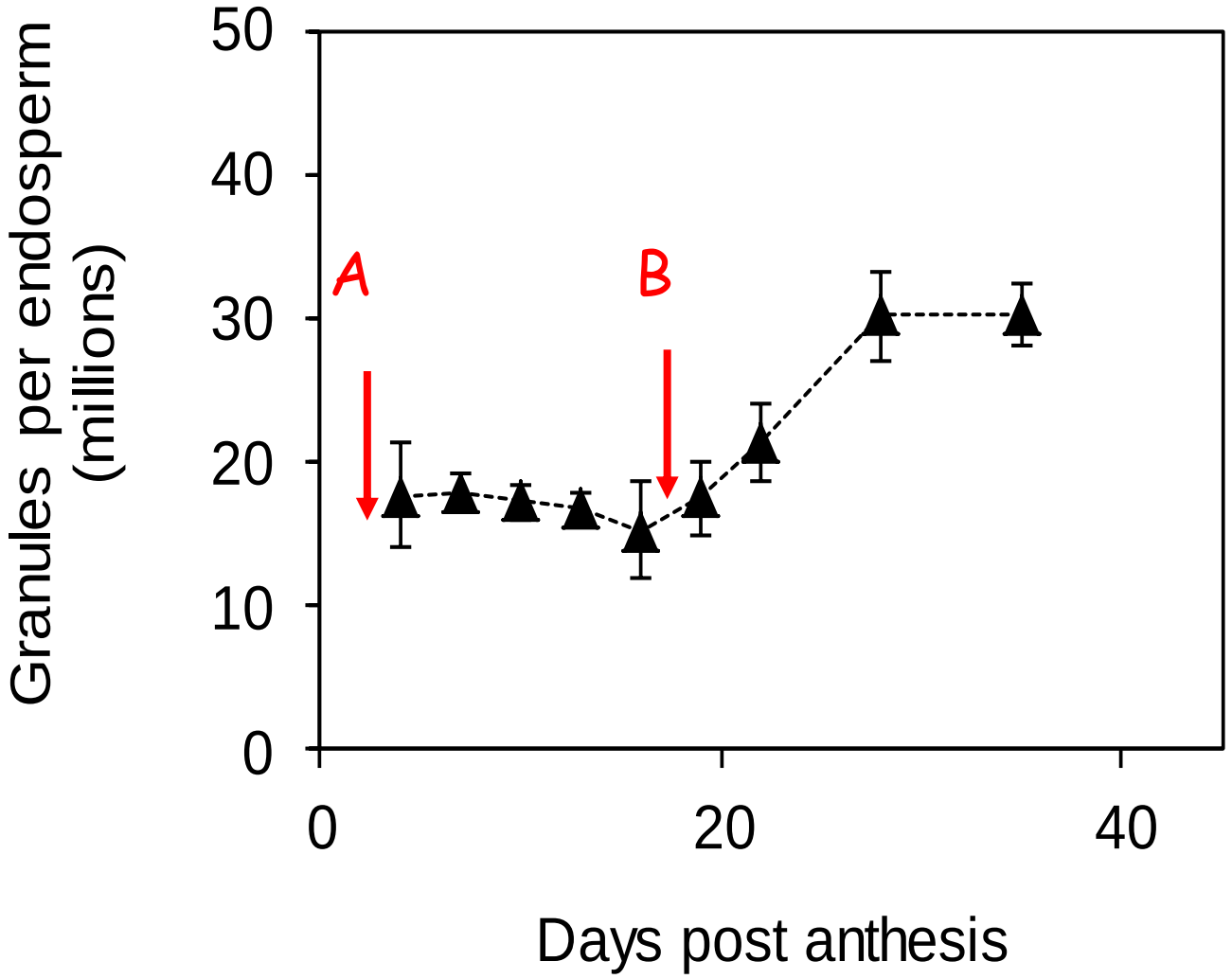


B-type

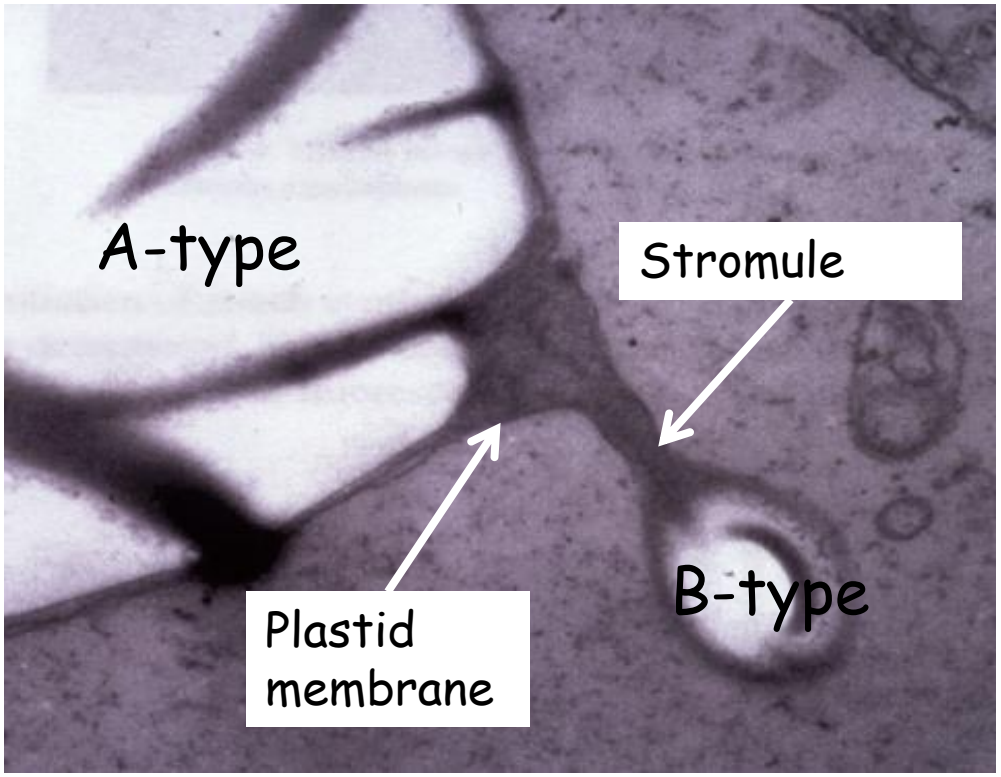
Small near-spherical

Similar types of granule are also found in wild wheats, barley and rye.

Granule initiation and growth in wheat



Granule initiation and growth in wheat



A- and B-type granules differ in:

- size
- shape
- time and location of initiation in the plastid

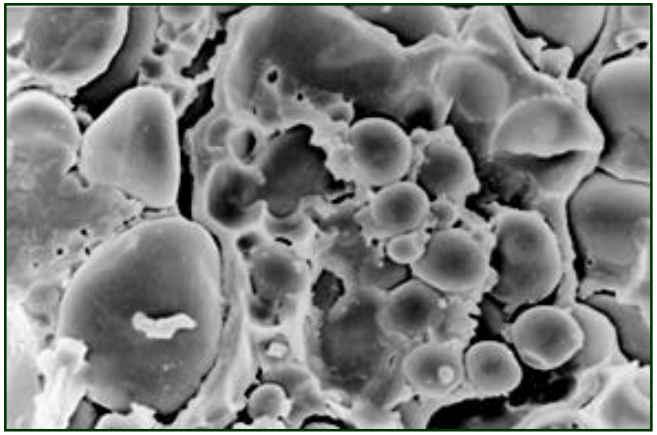
Wheat/barley lacking B-granules may be useful

- B-granules degrade during malting.
- Only half of the B-granules are broken down during mashing
  - represents a loss of 5% of total starch.
  - B-granules cause a 'starch haze' that can cause filtration problems.
- Small starch granules are easily lost in waste stream during starch purification.

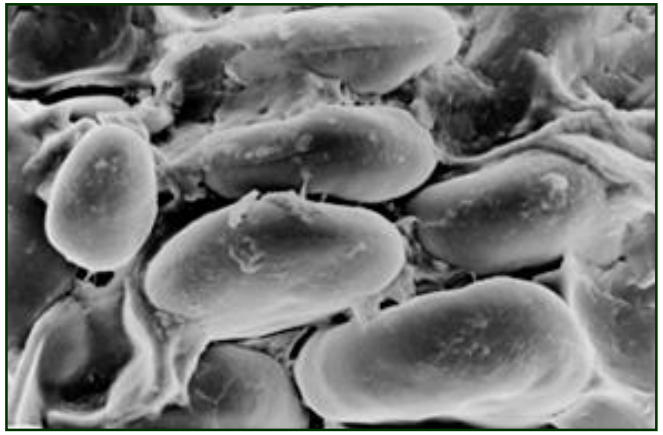
Conclusion: Lack of B-granules would be advantageous

Variation in granule-size distribution

200 hexaploid wheat and 99 *Aegilops* accessions were screened for variation in granule size distribution (Stoddard & Sarker, **2000** *Cereal Chem.* 77:445).



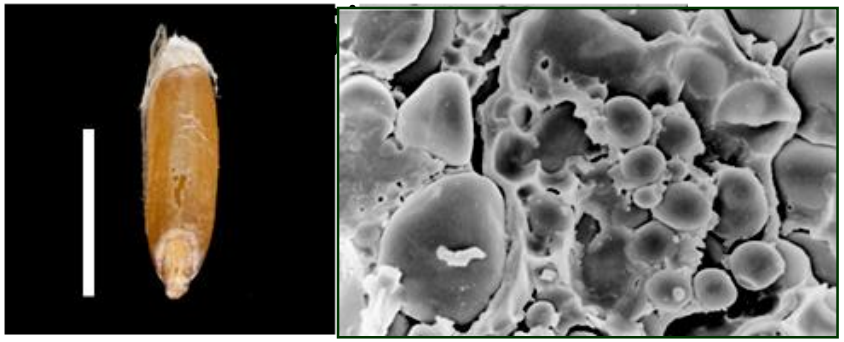
All hexaploid wheat and most *Aegilops* species had A and B-granules.



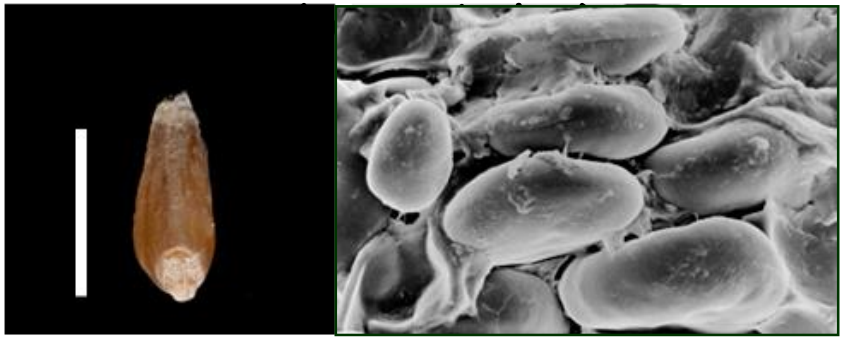
Five *Aegilops* species had A-granules only, no Bs

Genetic analysis of B-granule content

Synthetic tetraploid



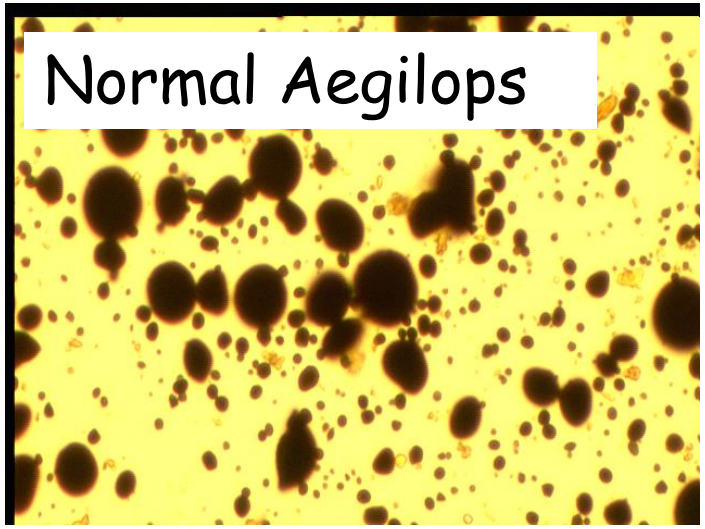
Aegilops peregrina

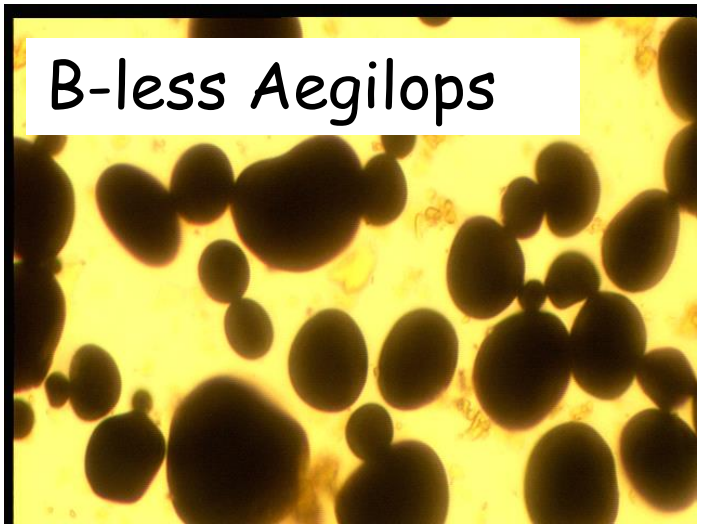


F_2 population

Phenotyping the F_3 grains.

Material was scratched from the endosperm of a mature seeds and stained with iodine.



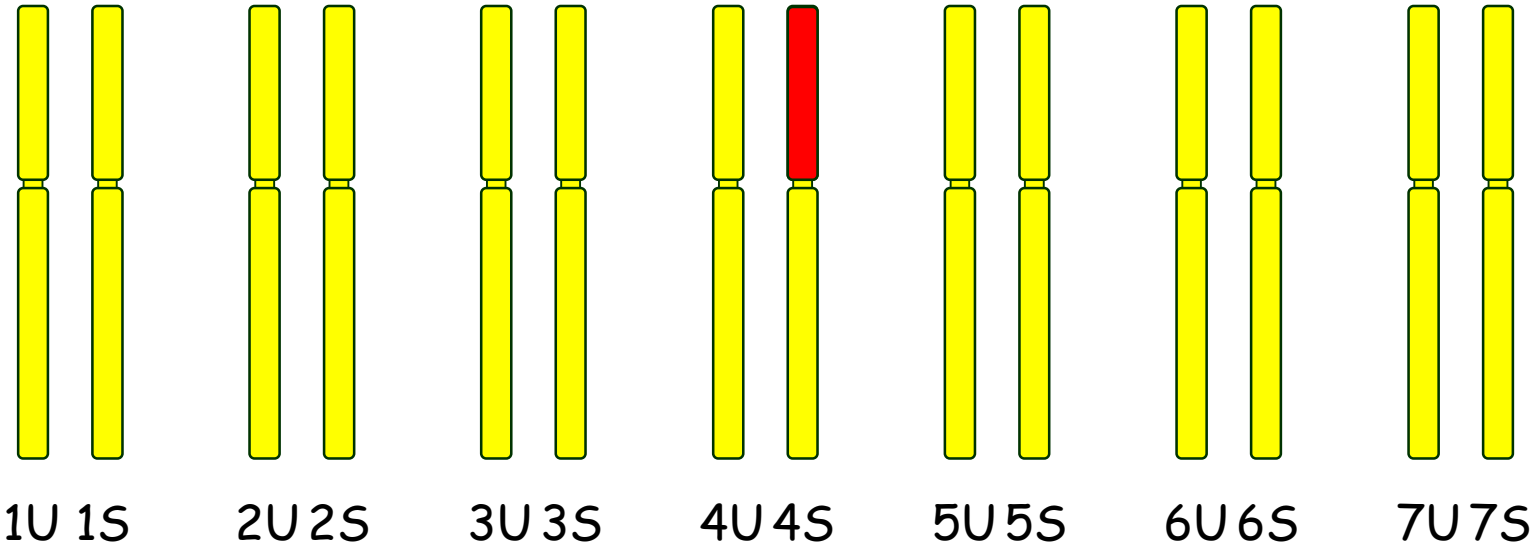


A and B granules

A granules only

Location of genes controlling B-granules

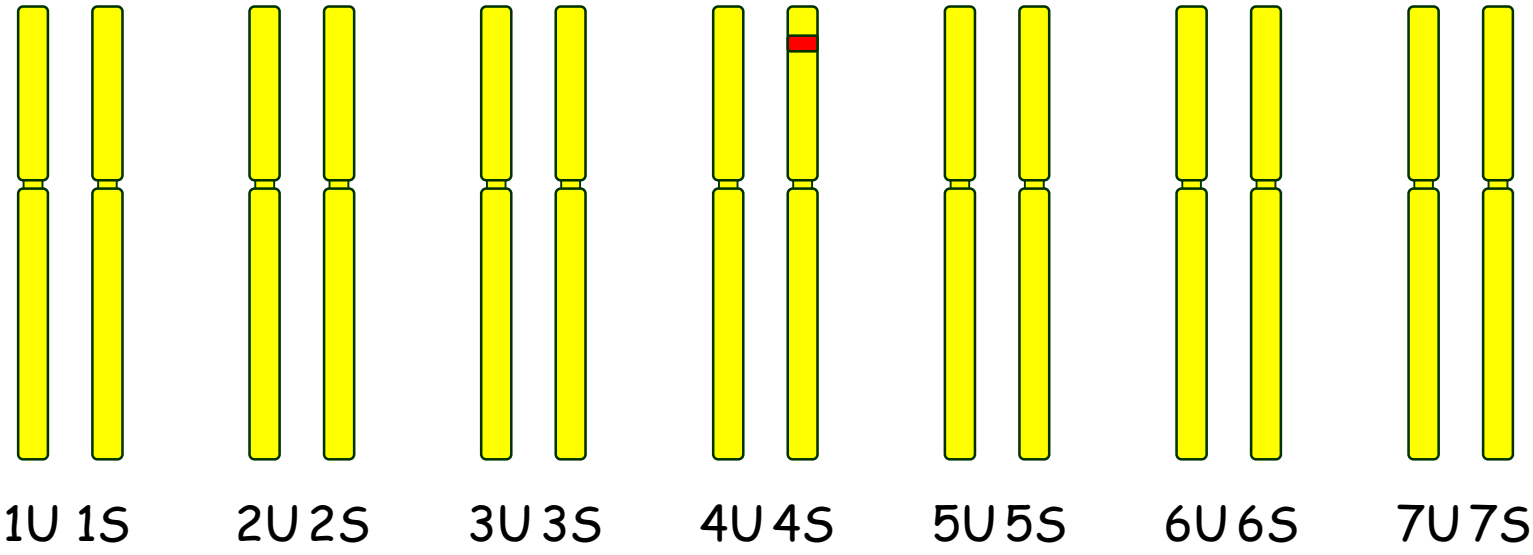
Aegilops-wheat addition lines



A locus Bgc-1 on the short arm of chromosome 4S is required for B-granule initiation.

Location of genes controlling B-granules

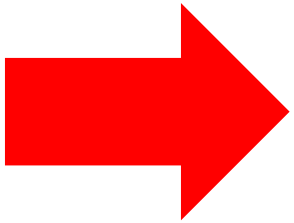
Fine mapping results



The region in wheat containing *Bgc-1* is predicted to contain

approx. ten conserved genes

How do we transfer trait from Aegilops to wheat?



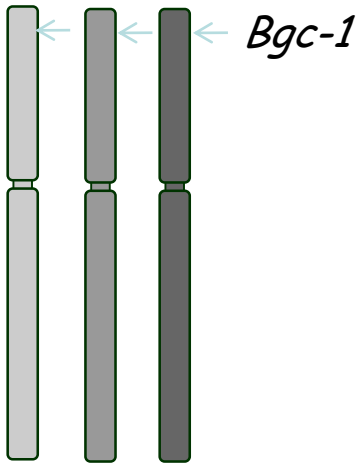
Aegilops peregrina
-Lacks B granules
Tetraploid genome US

Triticum aestivum
Has A and B granules
Hexaploid genome ABD

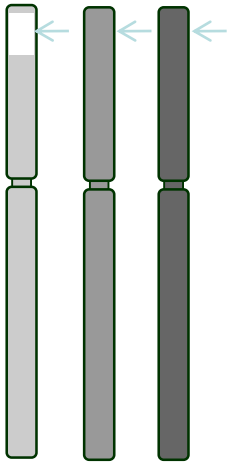
Deletion mutants in wheat

Position of *Bgc-1* in wheat

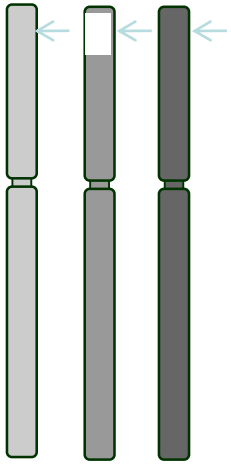
γ-irradiated Paragon *mutant population supplied by Simon Griffiths, JIC.*



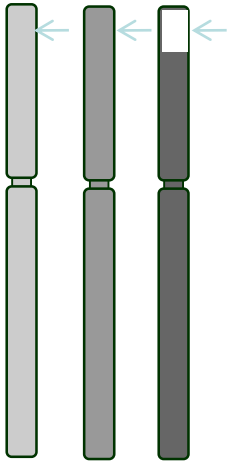
4A 4B 4D
Wild type



A null



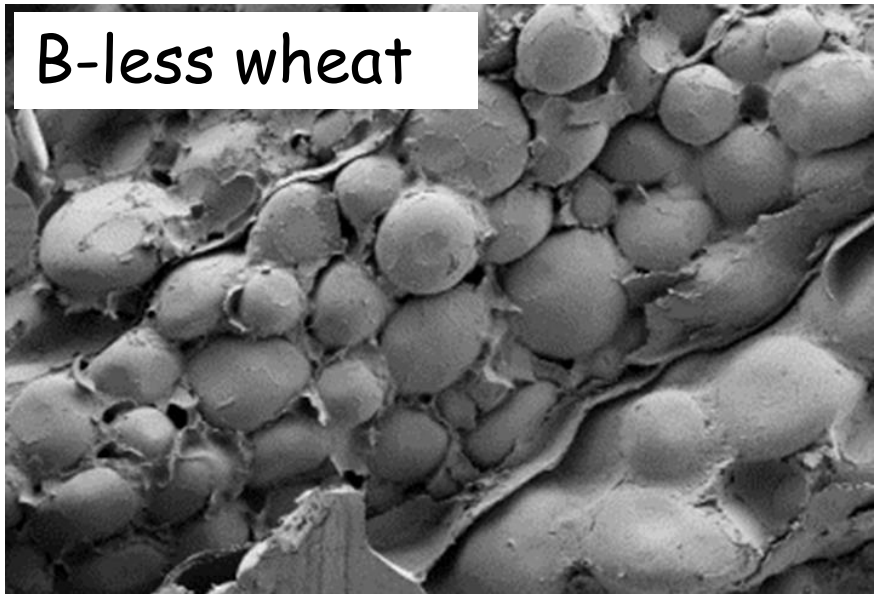
B null



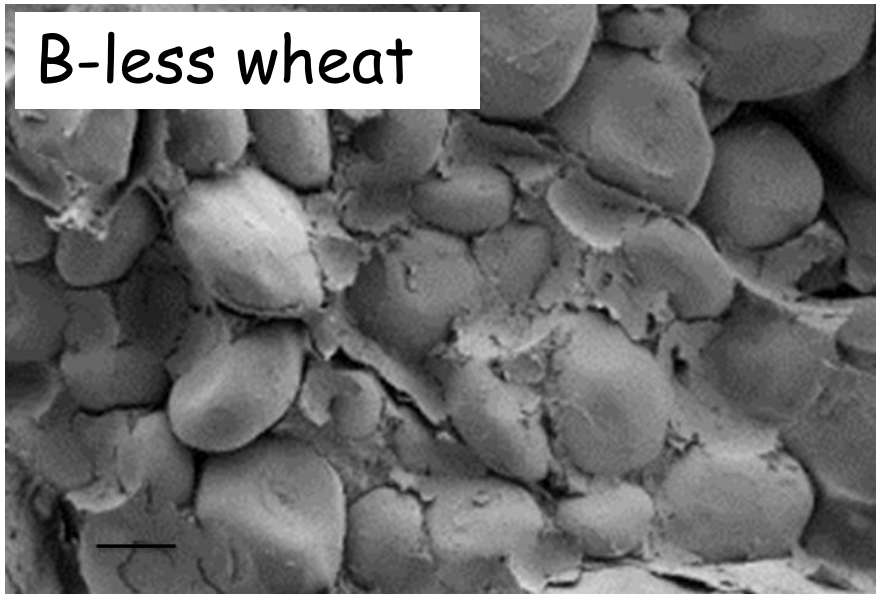
D null

Combine by crossing to give double- and triple-deletion mutants

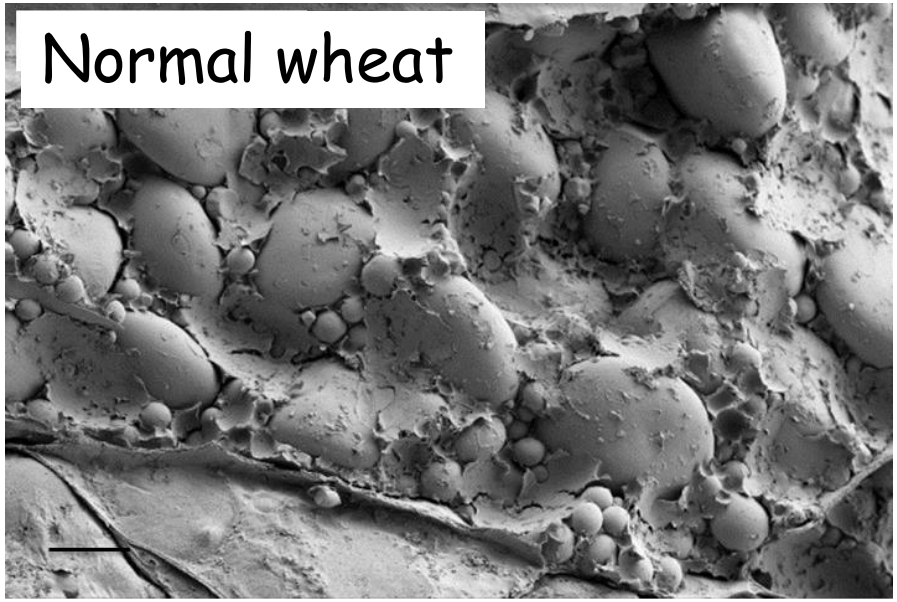
B-less wheat



B-less wheat

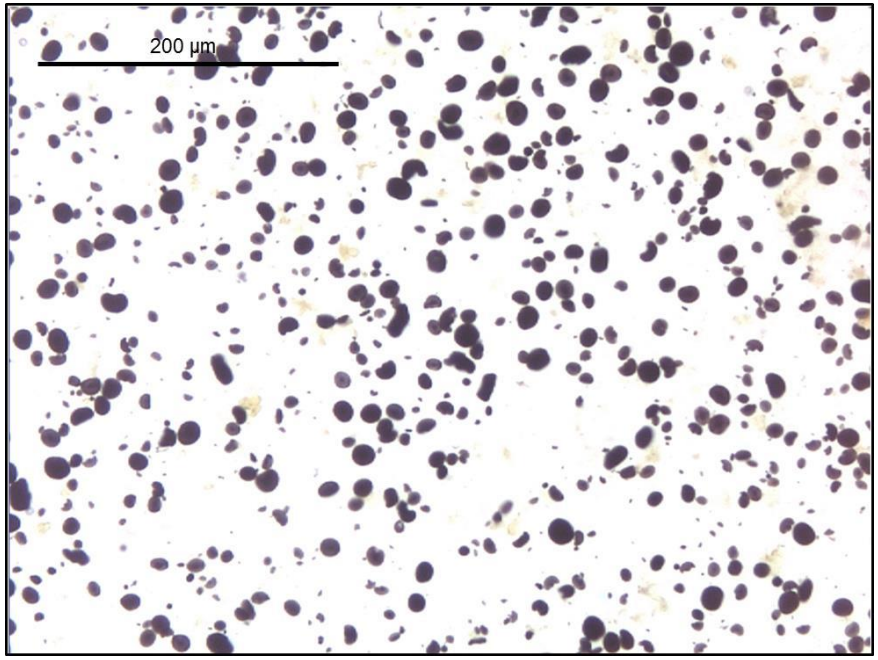


Normal wheat

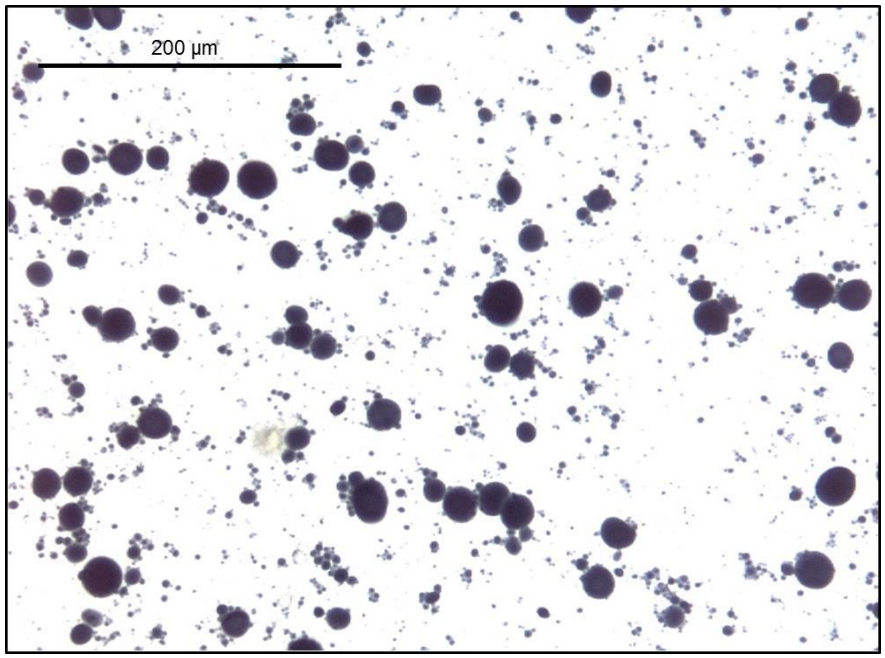


Deletion mutant grains lack B-type starch granules.

Light microscopy of starch from mature grains.

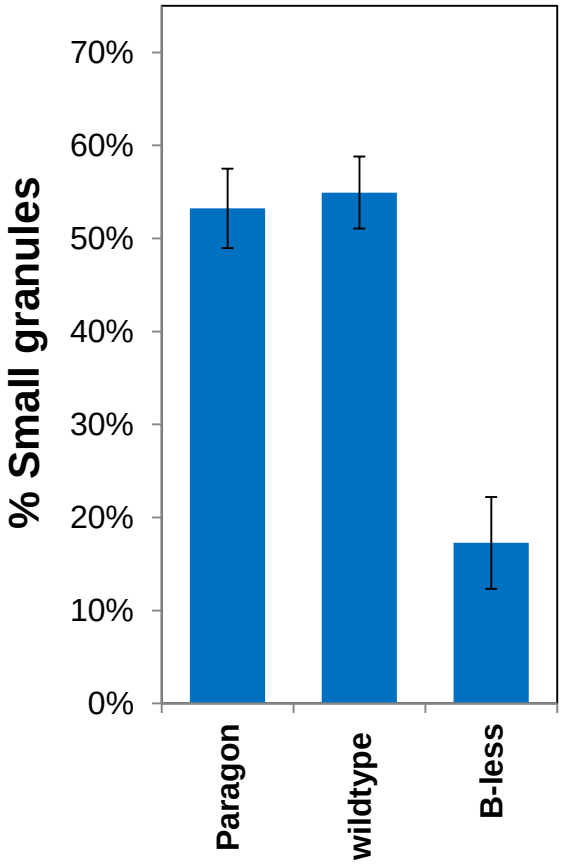


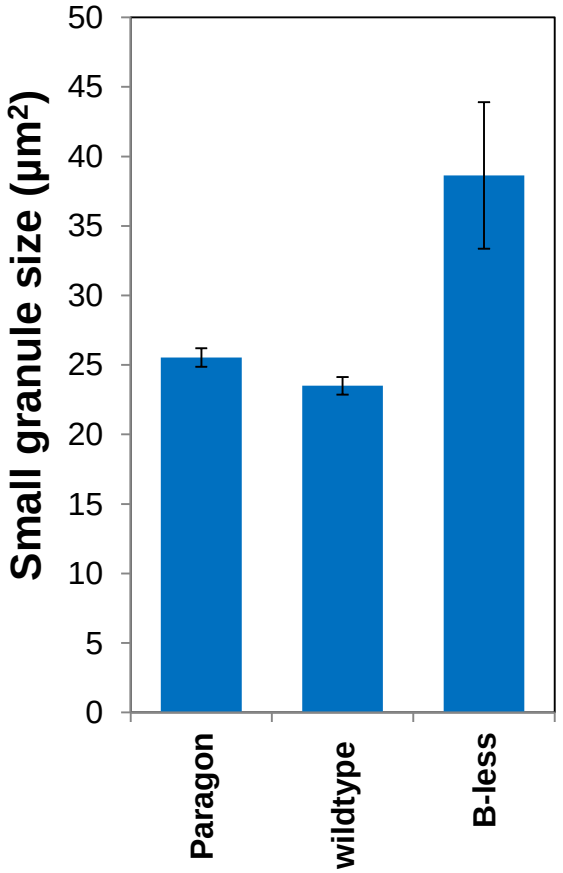
B-less wheat



Normal wheat

Deletion mutants: starch granule size

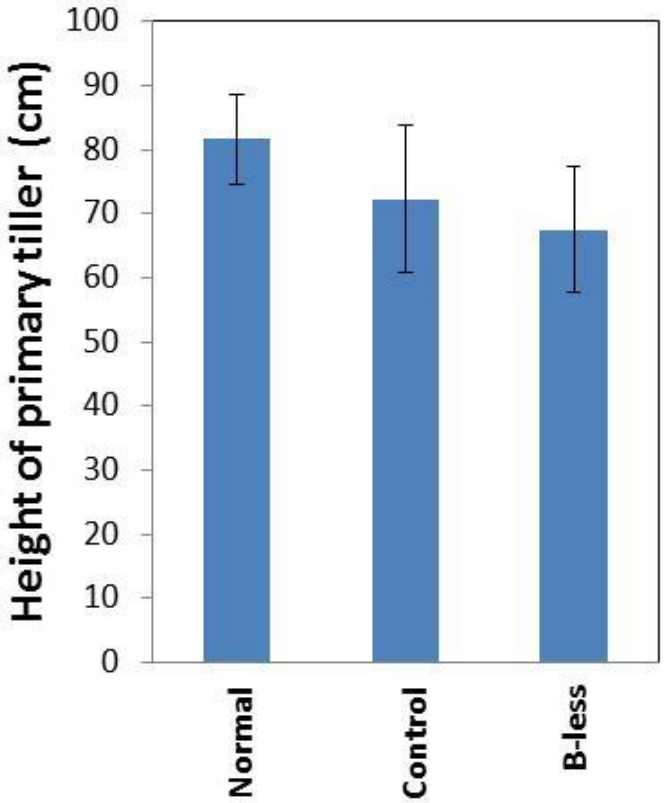


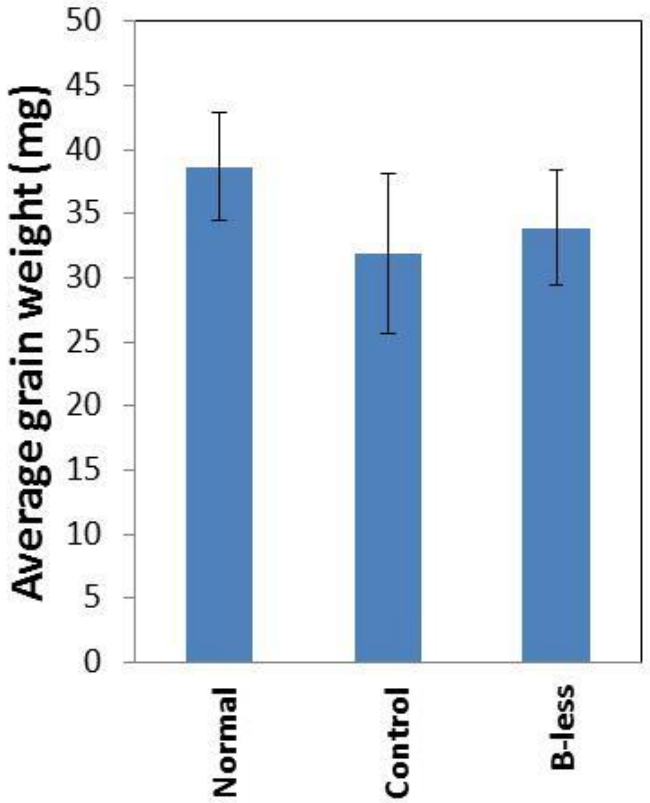


B-less mutants have fewer small granules (probably small A-granules only)

Phenotyping B-less plants

~30 plants, Glasshouse-grown





Lack of B-granules does not affect grain weight

We have increased genetic diversity in wheat

Although we have not yet identified the *Bgc-1* gene, we have transferred a starch quality trait previously only available in wild wheat to cultivated Triticeae species. Preliminary tests suggest that B-less grains/starch have novel functional properties.

Acknowledgements

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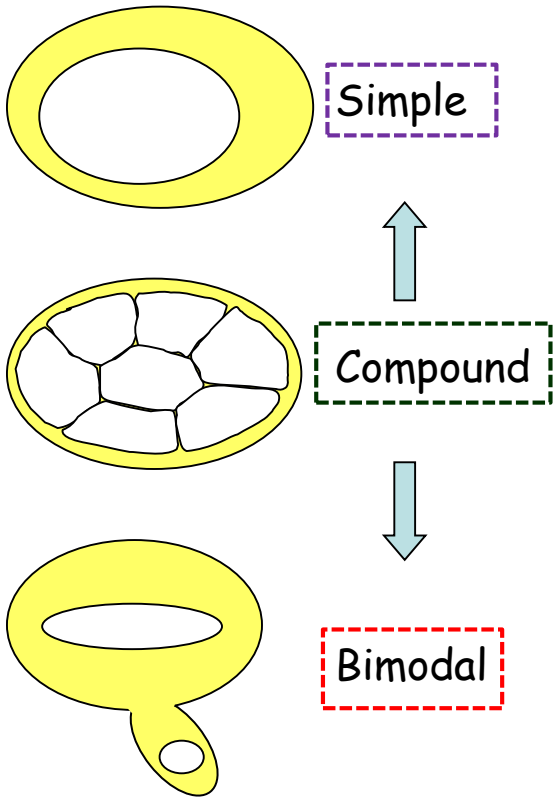
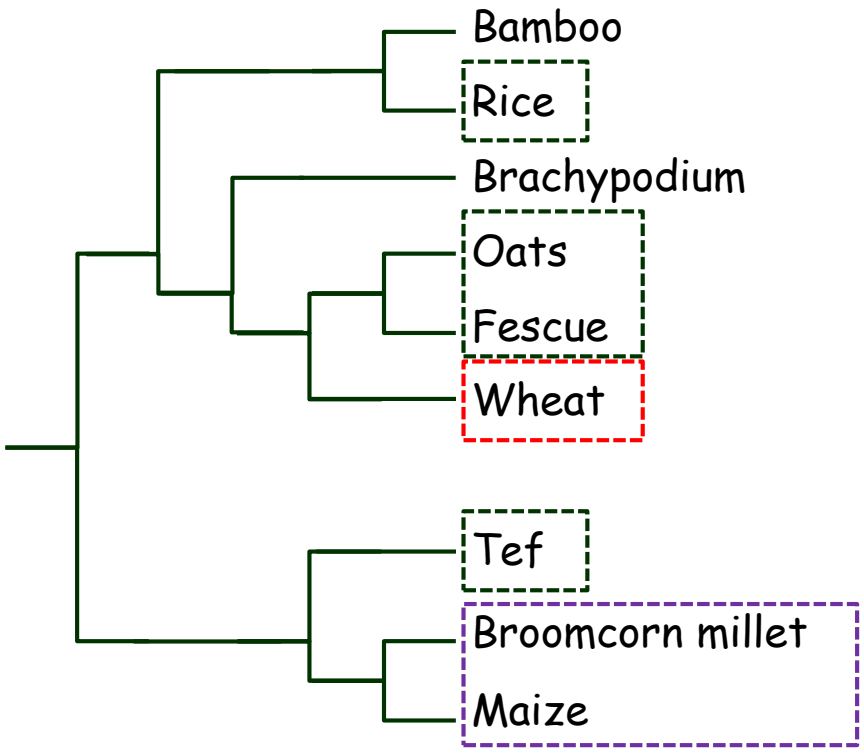
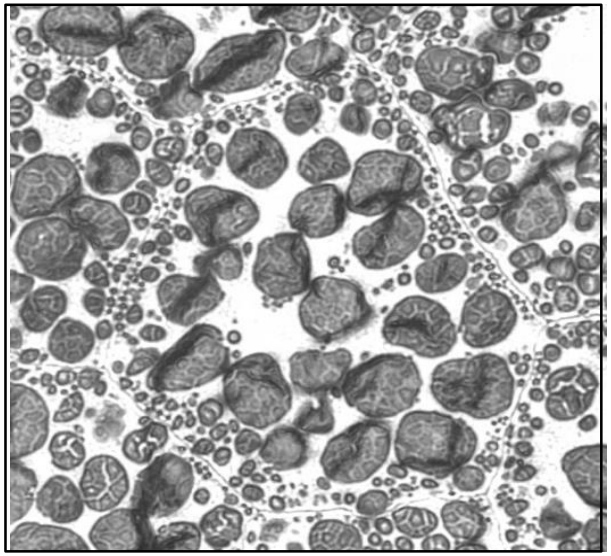
Granule Morphology in Cereal Endosperm



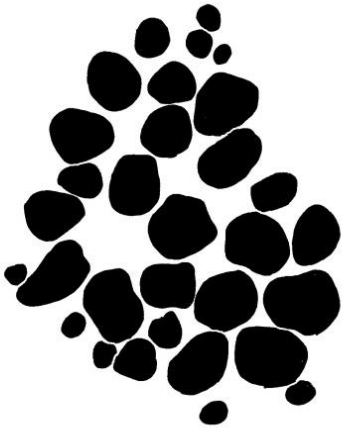


During evolution, the number of granules per plastid has been reduced twice independently

Granule morphology in oat endosperm



Compound granules



Simple granules

In oats, compound and simple granules both initiate early in grain development.