

Development of wheat and triticale genotypes with novel starch characteristics

Sai L.K. Hsam

Department of Plant Breeding
Technical University of Munich
Freising-Weihenstephan

Weihenstephan- oldest brewery in the world

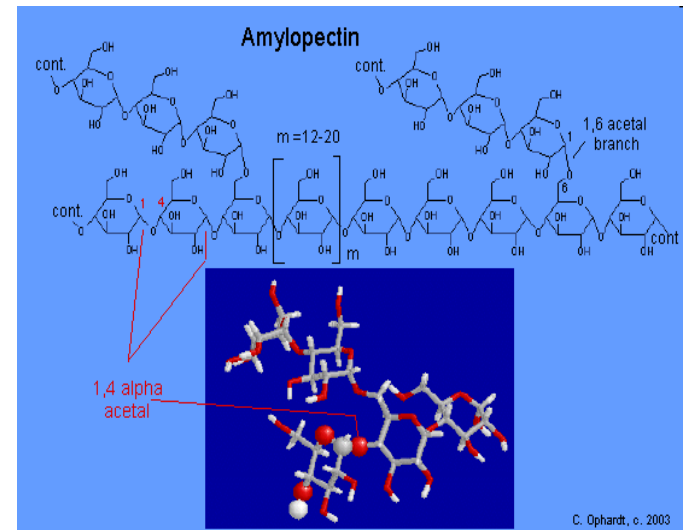
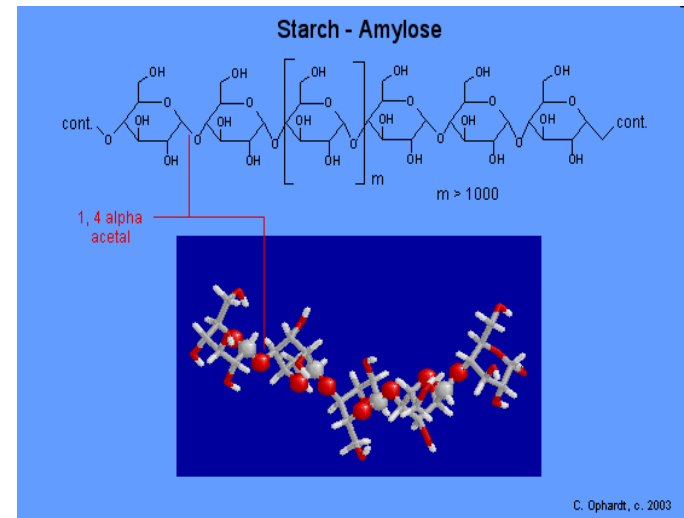


Intrinsic starch qualities

- Content (concentration)
- Granule size
- Amylose and amylopectin
- Crystallinity, helices
- Proteins on and in granules
- and some others

Starch

- Alpha-1,4 linked glucan chains with alpha-1,6 branches
- Energy storage in seeds, tubers etc.
- Low water content
- Important in diet



Starch Production

EU (2008): 9.4 Mio. t

(maize- 47%, wheat-37%, potato- 16%)

40% of starch used in non-food industries

- 23% used in native form

- 77% used after chemical or physical modification

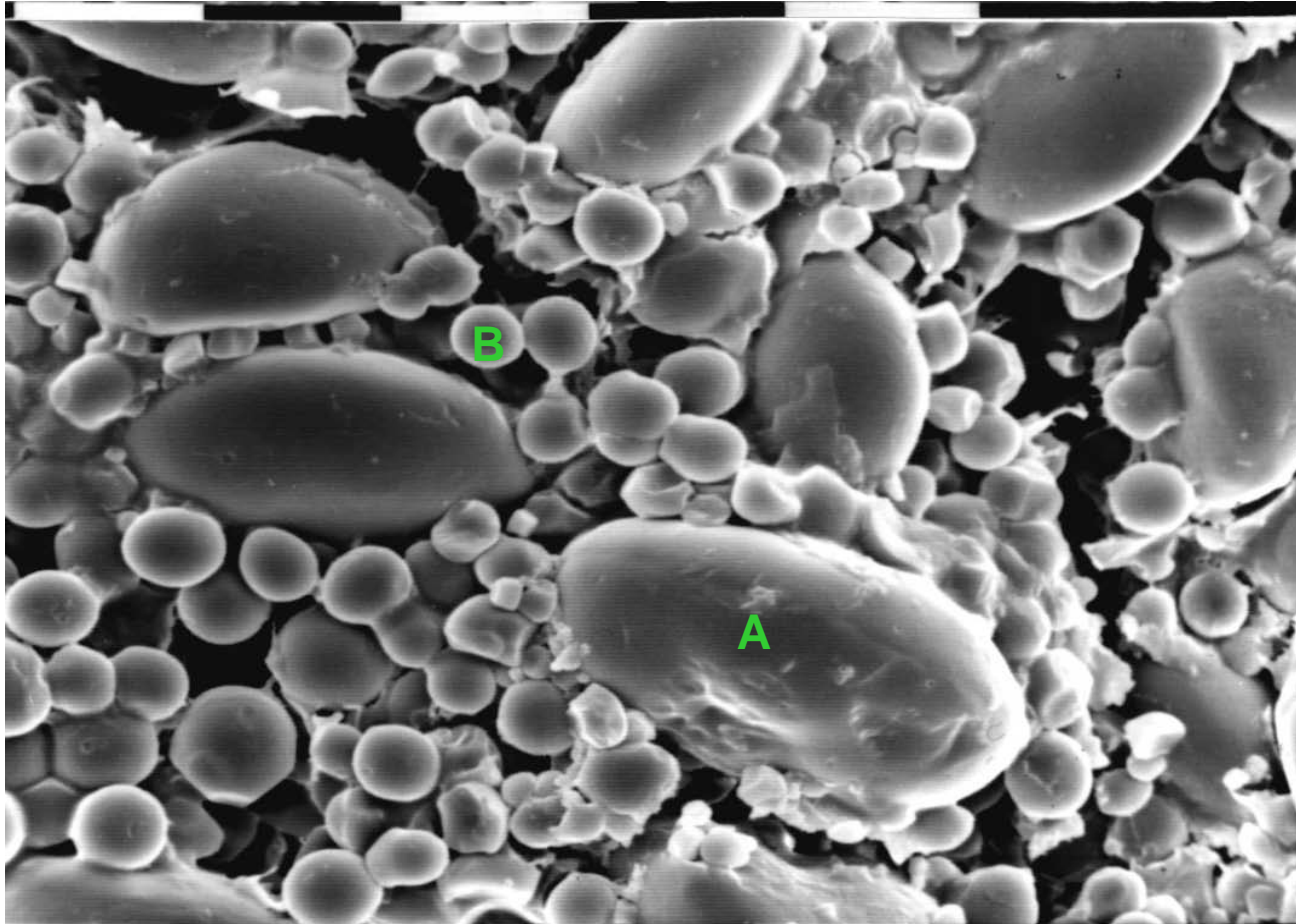
GER (2008): 1.53 Mio. t

(potato- 42%, wheat- 33%, maize 25%)

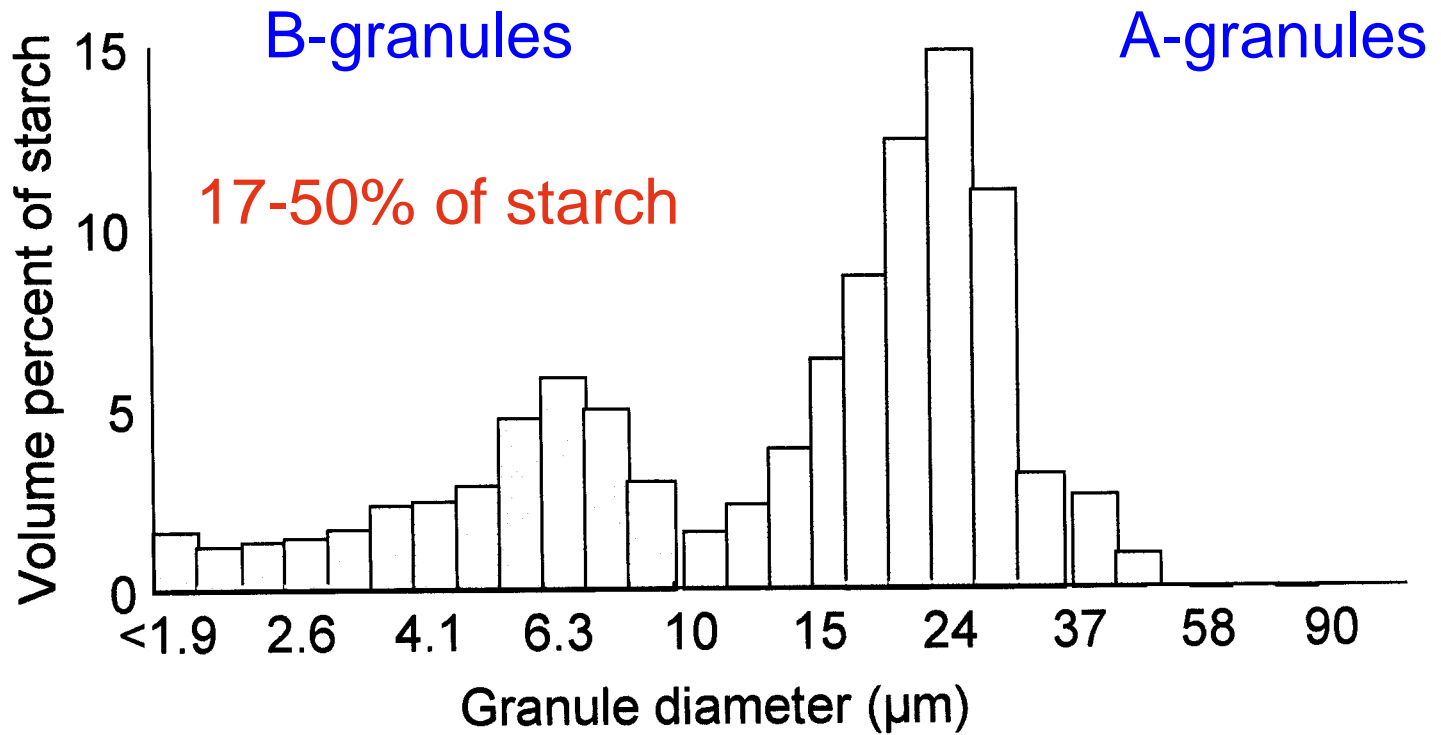
Granule size

Species	Average diameter (μm)	Shape
Potato	30-40	Irregular sphere
Wheat, barley, rye A	25	Flattened sphere
Wheat, barley, rye B	5	Sphere
Maize	15	Polyhedron
Oat (compound)	5	Polyhedron
Rice (compound)	3	Polyhedron

Starch granules



Common and durum wheats

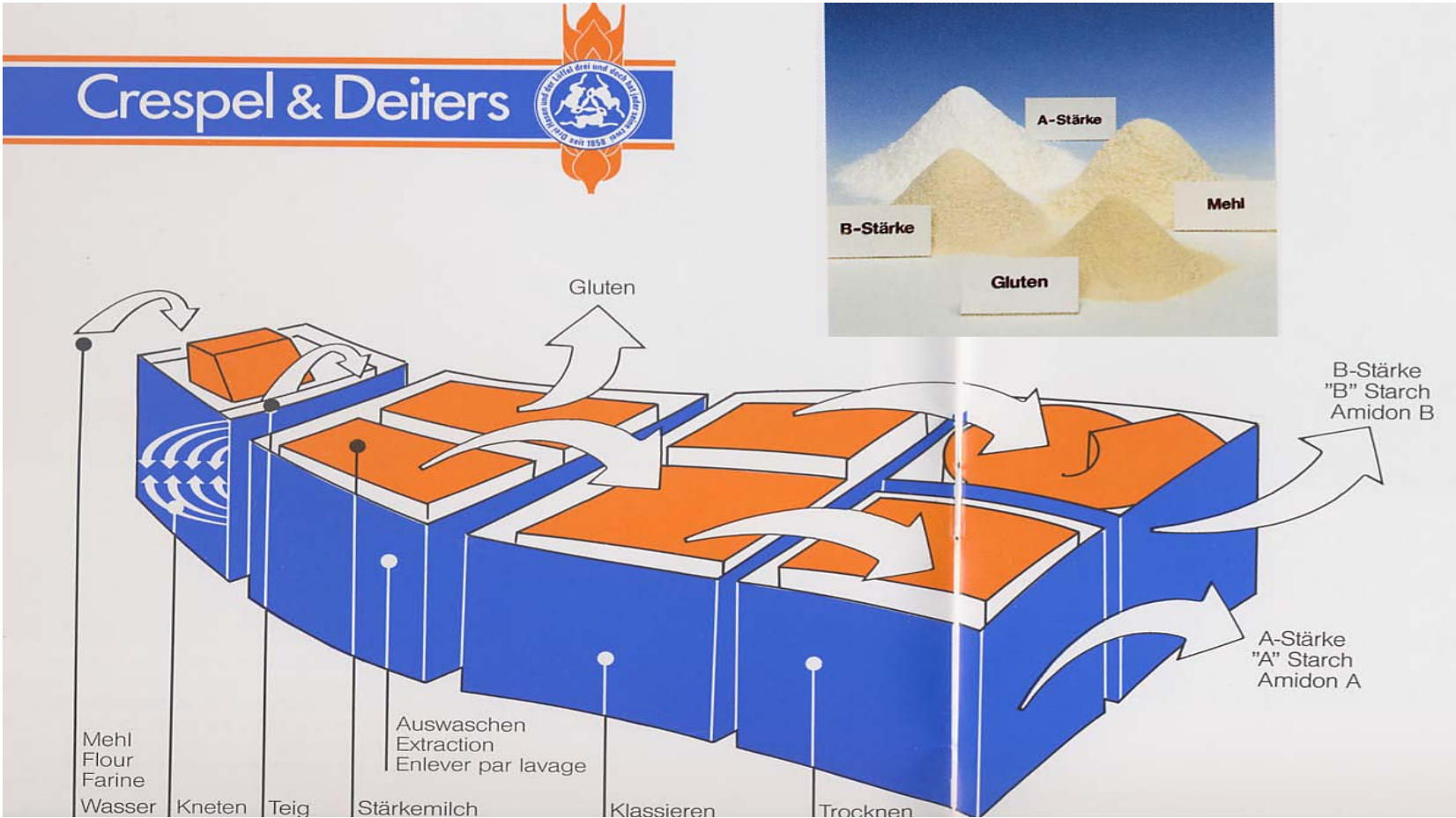


Importance of granule size

Different industrial uses for different sizes

- **Large A- granules** in wheat
 - Starch manufacture
 - Biodegradable plastic film
- **Small B- granules** in wheat
 - used as fat substitutes
- **High A-granule content** maximizes starch recovery during processing

Starch processing at C & D



Sources of variation

Species

- Remember that wheat is a hexaploid comprised of 3 ancestral diploid grasses with genomes A,B and D

Genotypes within species

Environment

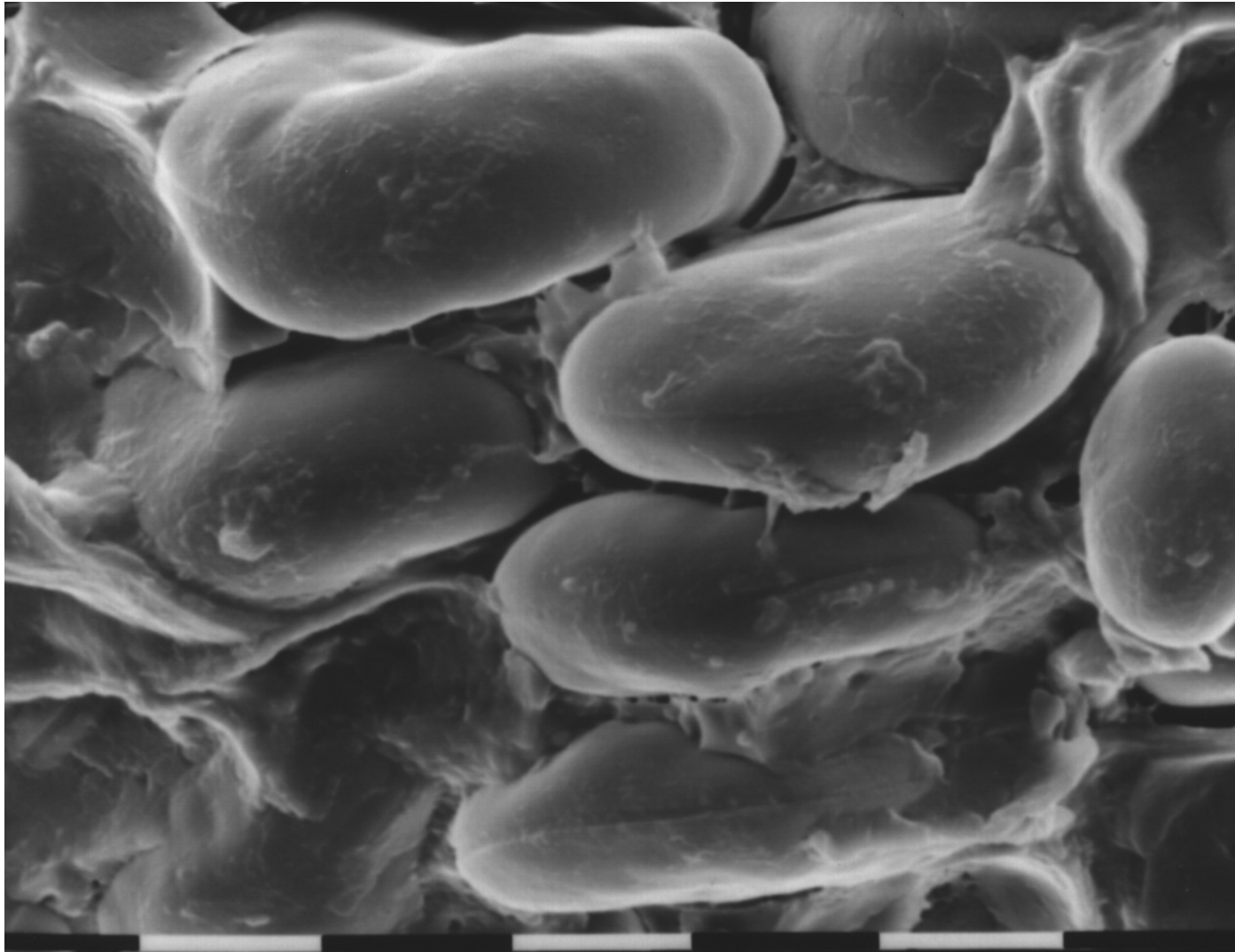
- Heat/drought stress during grain filling
- Premature termination of grain filling

Genotype x Environment

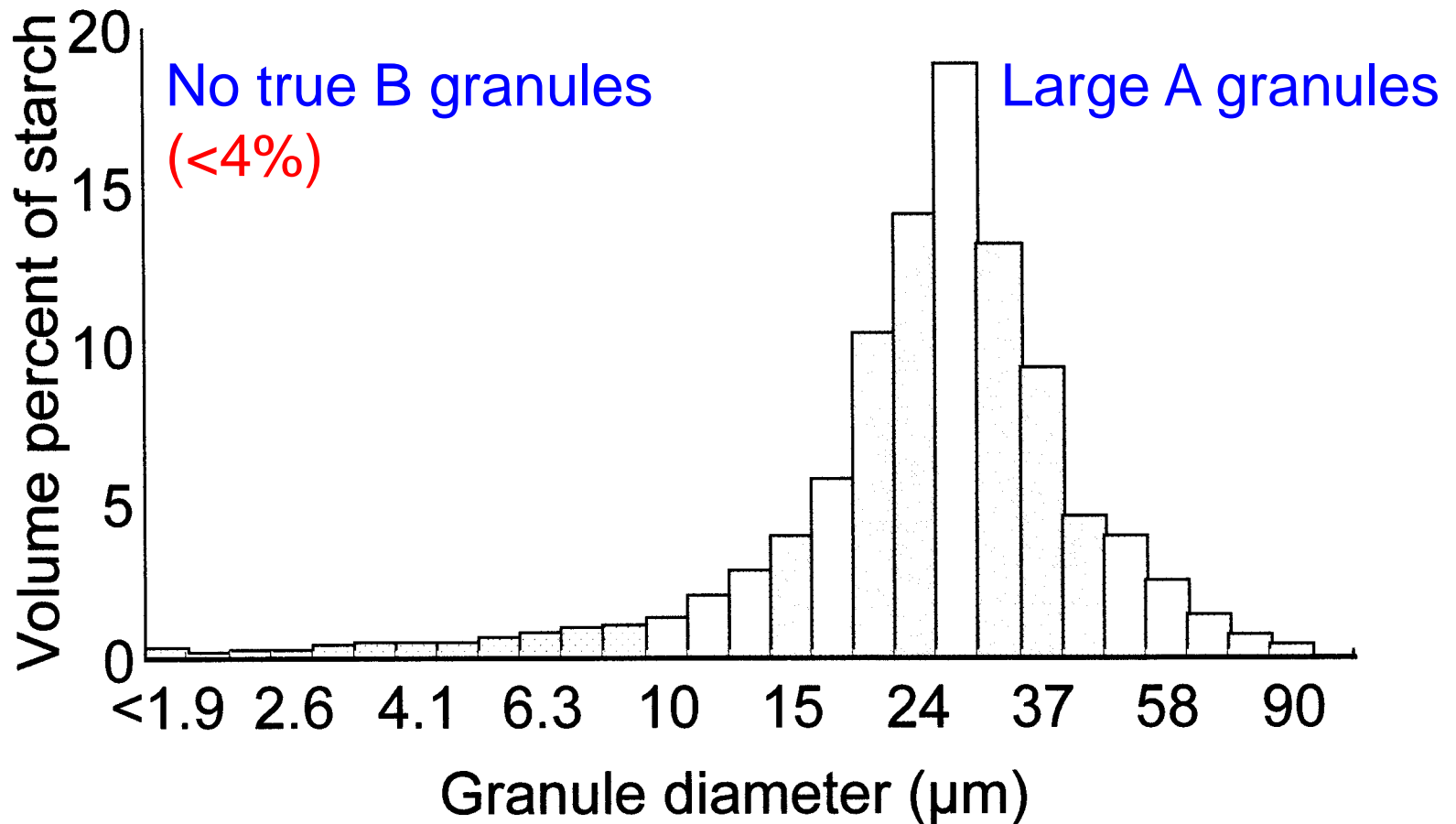
A- granules in wheat and *Aegilops*

Common & most durum wheats	= 50-77% of starch
<i>T.aestivum</i> subspecies	= up to 83% of starch
Triticale (AABBRR) & rye (RR)	= up to 85% of starch
AA genome wheats	= up to 40% of starch
SS and DD genome wheats	= up to 85%
<i>Ae. crassa</i> (DDSS)	= no true B granules
<i>Ae. peregrina</i> (UUSS)	= no true B granules

Aegilops peregrina & *Ae. crassa*



Ae. peregrina & *Ae. crassa*



Crosses between CS & *Ae. peregrina*

6x- CS wheat x 4x- *Ae. peregrina* (Apr)

CS- Apr F1

colchicine treatment

CS x CS- Apr. C1

CS-Apr. BC1F1

CS-Apr. BC2F1

Chromosome numbers = 50 -70
A- granules content = 65 – 90%



Apr.

CS

Ae. crassa

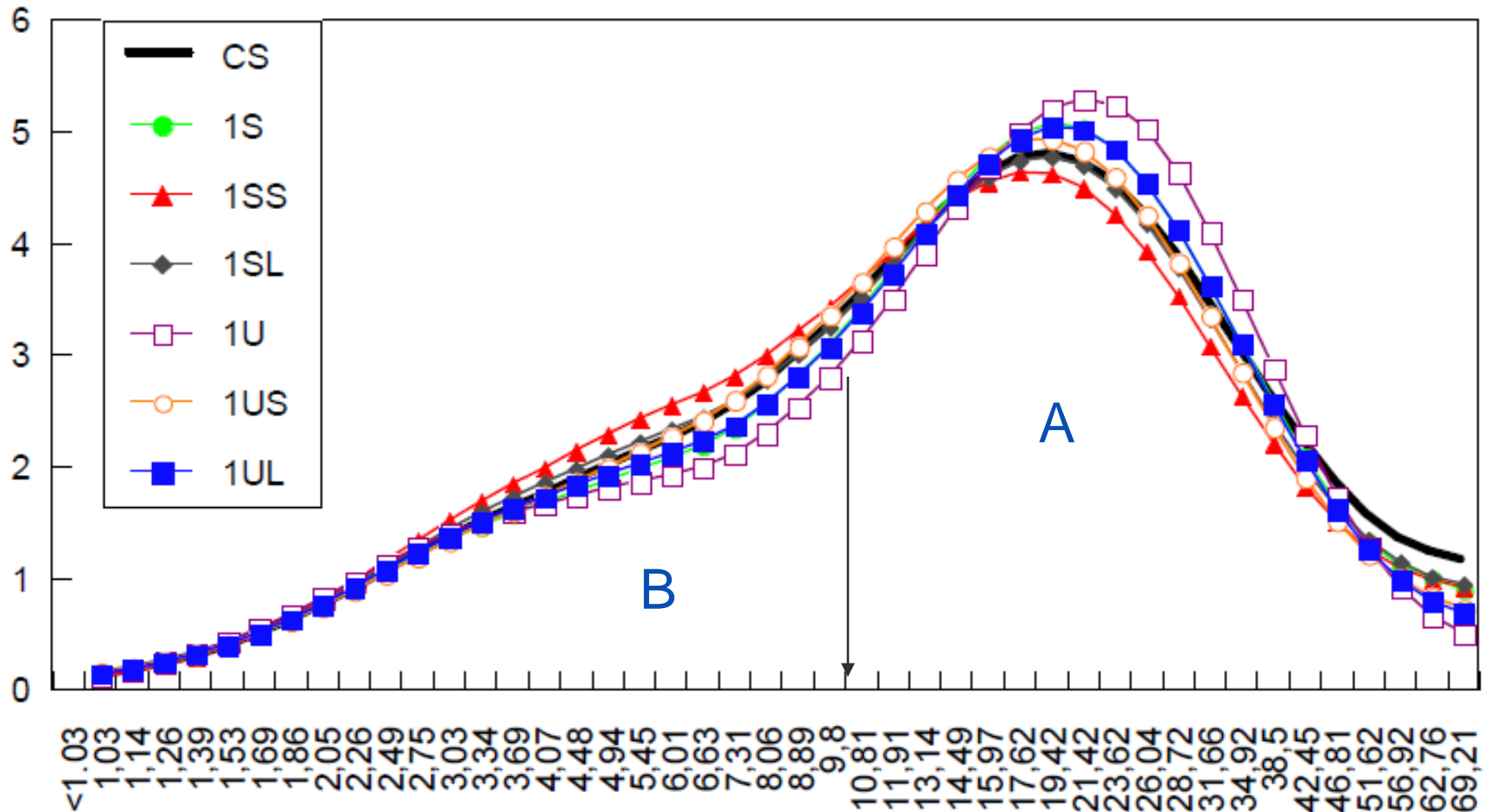
CS-*Ae.peregrina* hybrids



Effect of *Ae. peregrina* chromosomes

- 39 *Ae. peregrina* additions & telosomic additions granules size distribution (Malvern Mastersizer S laser-diffraction analyser)
- 6 chromosomes/arms increased A- granules
1UL, 2US, 3US, 7U + 2SS, 6SS
- 2 chromosomes/arms increased B- granules
1SS, 7S

CS- *Ae. perigrina* additions & telo additions



Summary: A & B Granules

- A & B starch granule contents depend on species and cultivar
- In *Ae. peregrina*
 - 6 chromosomes increased A-granules
 - 2 chromosomes increased B- granules
- Introgression of this trait into wheat is possible but laborious.

Synthesis of waxy triticale

Materials:

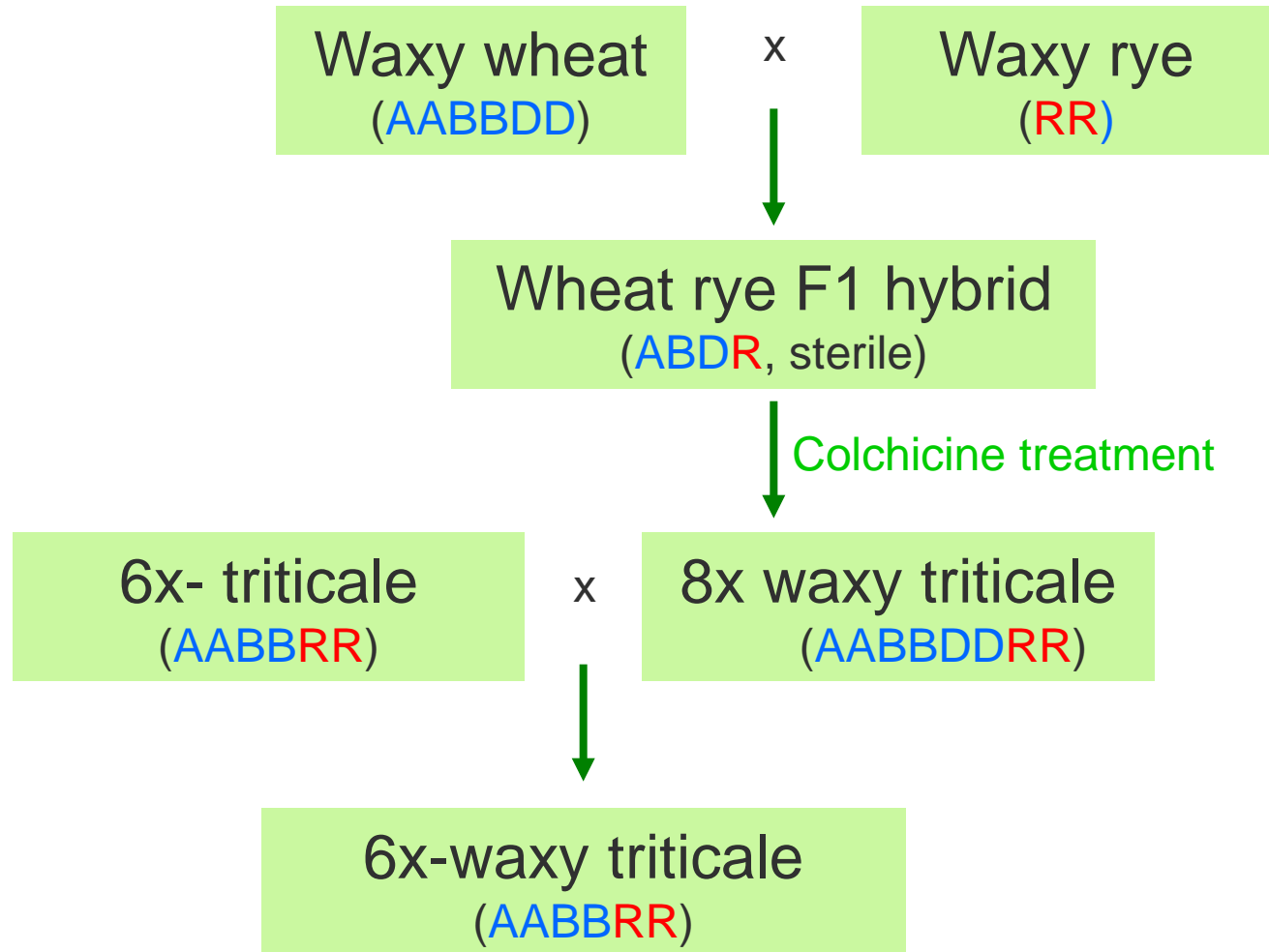
Hexaploid waxy wheat

- **waxy loci**: *wx-A1* (**7AS**), *wx-B1* (**4AL**),
wx-D1 (**7DS**)

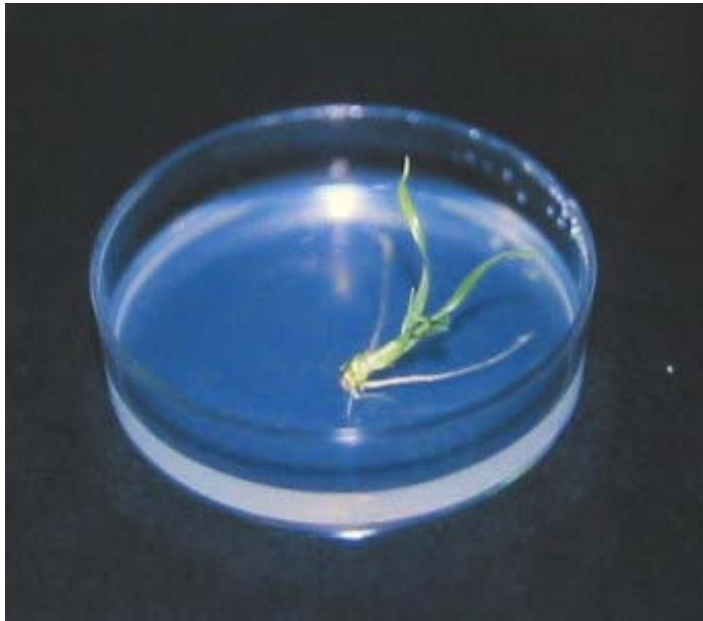
Diploid waxy rye

- one self fertile waxy rye mutant (MLRM1)

Crossing scheme

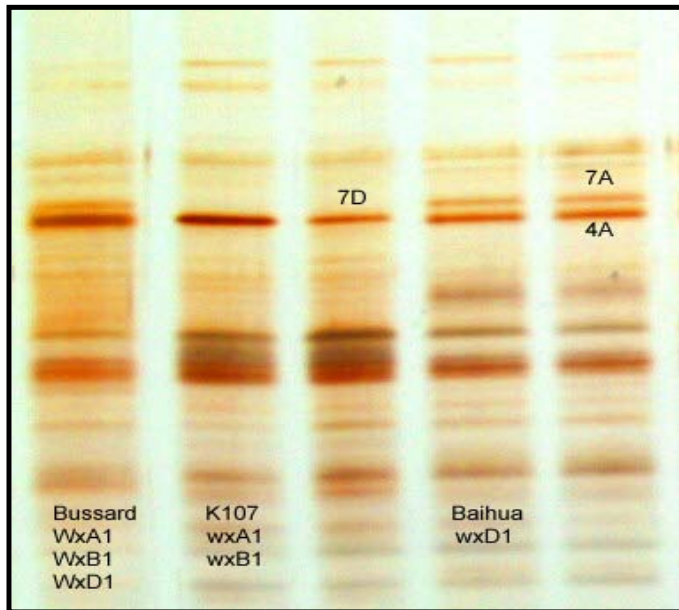


Embryo culture and colchicine treatment



SDS-PAGE of wheat and waxy triticale

Lack of Granule Bound Starch Synthase (GBSS) activity results in waxy cereals



Bussard

wx-triticale

Seeds of waxy wheat, rye and triticale



Wheat

Rye

Triticale



wx-6x Triticale

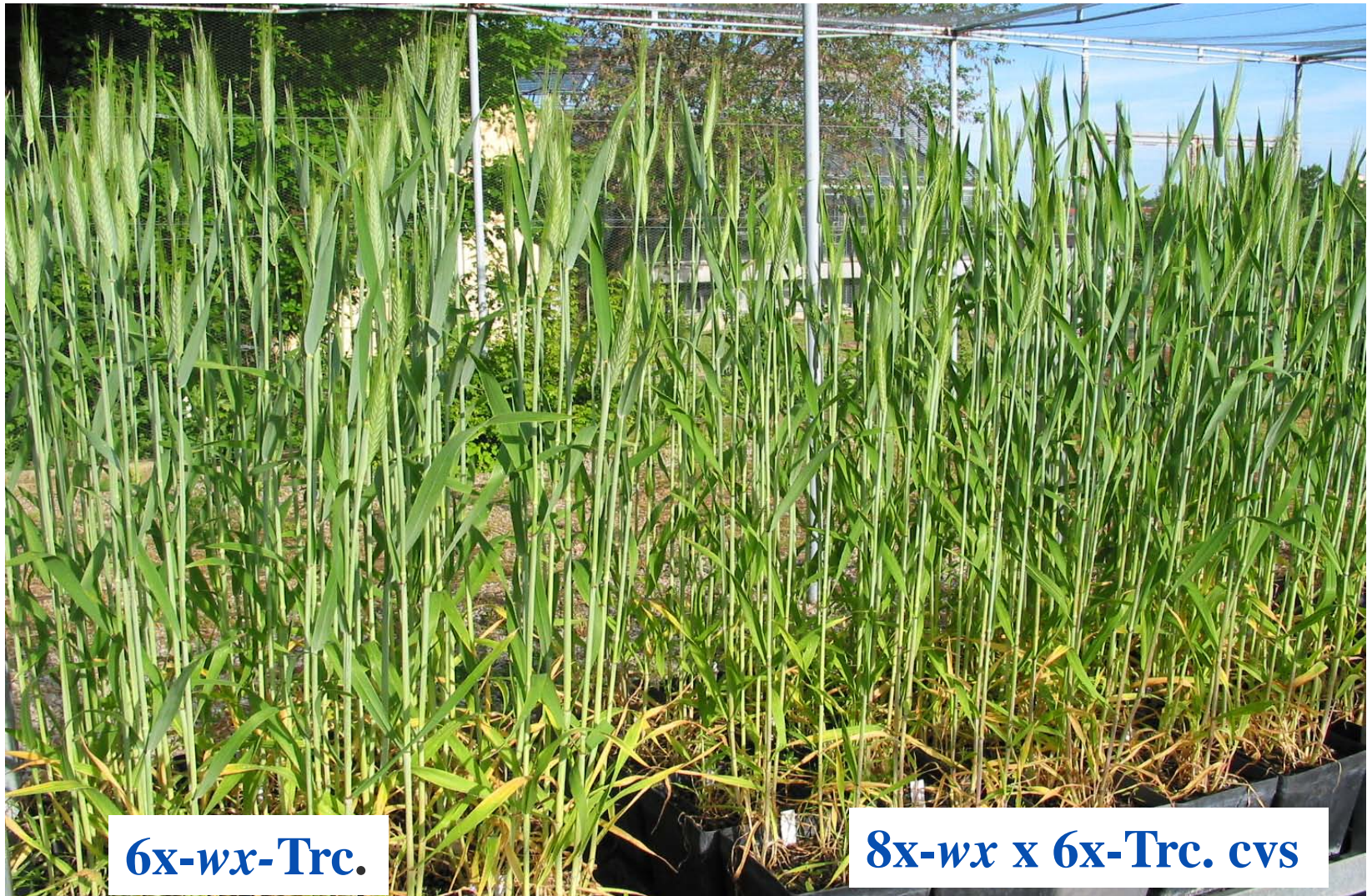
6x-Triticale

Hybrids of 8x- triticales and 6x- triticales

Description	Fidelio	Lasko	Logo	Modus
No. of F2 lines available	14	22	16	15
No. of F2 seeds analysed	1154	1735	1133	1714
No. of waxy seeds	18	10	15	25
No. of hexaploid waxy plants	3	2	2	6

SDS-PAGE method of Zhao and Sharp (1996) and Iodine staining were used to test for waxy characteristics

Waxy hexaploid triticales



Summary : waxy triticales

- Waxy wheat mutants have been studied since the 1990s
- Here we report on waxy rye and waxy triticales
- Further backcrossing to commercial cultivars is in progress

Acknowledgements

Financial support:

- The Federal Ministry of Food, Agriculture and Consumer Protection (BMELV)
- Agency for Renewable Resources (FNR)

Thank you for your attention.