

# Effect of “Novel” High Molecular Weight Glutenin Subunits Combinations on Gluten Strength, Dough Rheological Properties and Baking Quality of Durum Wheat

4<sup>th</sup> ICC Latin American Cereals Conference

13<sup>th</sup> International Gluten Workshop

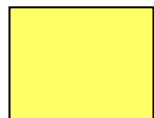
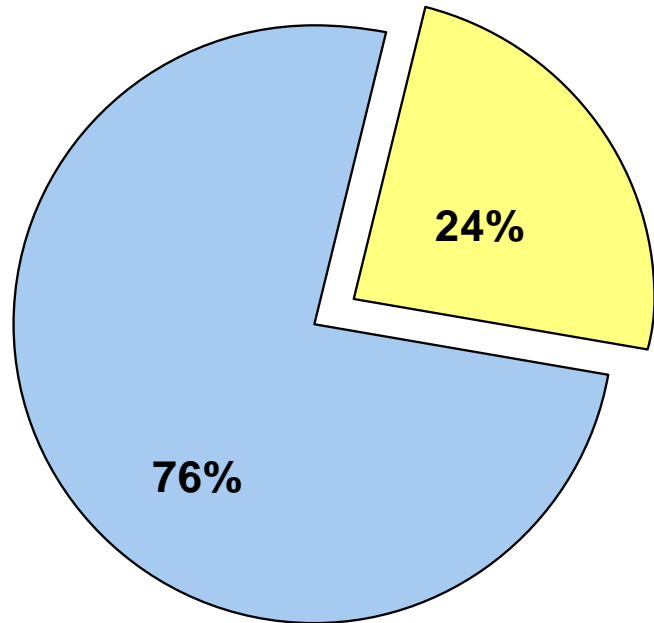
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Mexico City, Mexico



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# Durum Wheat Worldwide

## Utilization



**Bread and other Products**



**Pasta Products**



# Durum Wheat for Industrial Bread-Making

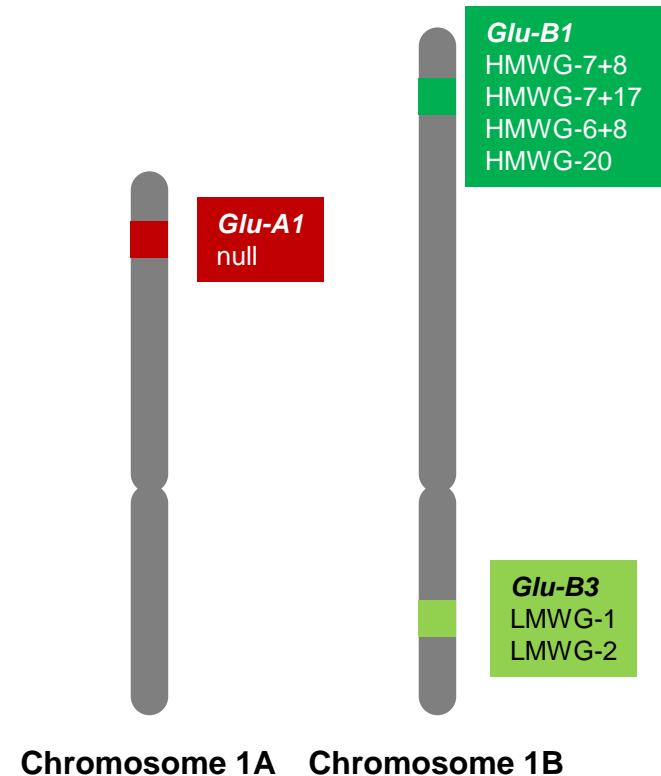
*Need for widening variability in components controlling gluten characteristics*

## ► Durum wheat for bread-making:

- Variability exist within modern germplasm
- Need to increase **strength** but mostly **EXTENSIBILITY**

## ► Glutenin subunits in modern durum germplasm:

- Very limited variability
- **Glu-A1**: Almost all durum have null allele, absence of **HMWG-1/2\*** which provide good baking quality in bread wheat
- **Glu-B3**: “weak pattern” LMWG-1 eliminated from most modern germplasm, but “strong pattern” LMWG-2 not enough for adequate strength/extensibility
- **Glu-B1**: Most variable locus in durum. Some combinations better than other for strength/extensibility, but **HMWG-17+18**, beneficial in bread wheat, absent in durum
- **Glu-D1**: Most influential locus in bread wheat, absent in durum, missing **HMWG-5+10 / 2+12**

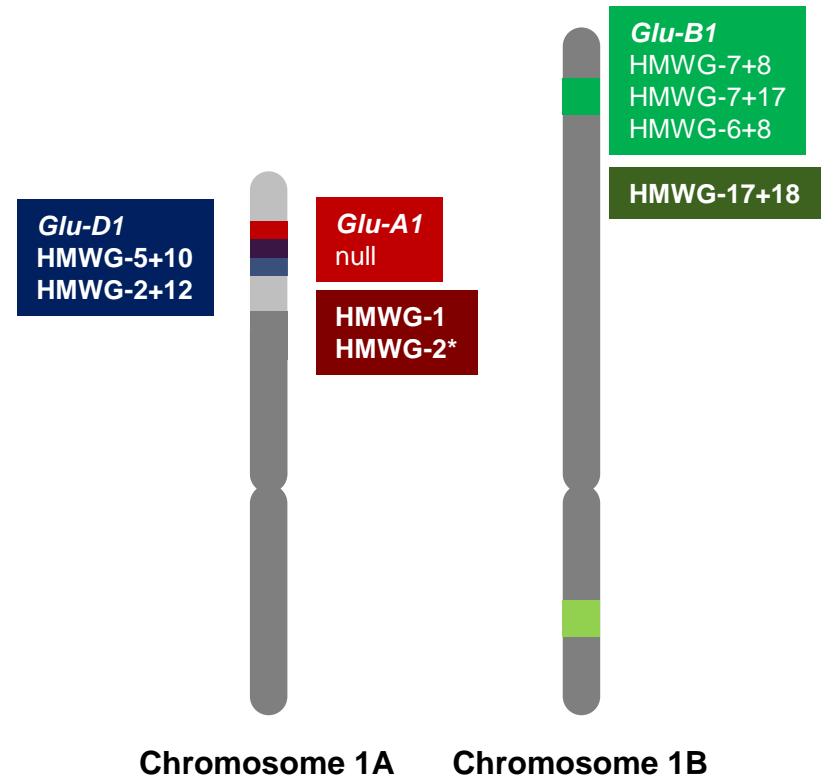


# Durum Wheat for Industrial Bread-Making

*Possible improvement via introgression of some HMWG glutenin sub-units*

► **Increase variability in Glutenin subunits in modern durum germplasm:**

- ***Glu-A1***: Introgress **HMWG-1** or **2\***
- ***Glu-B1***: Eliminate HMWG-20 and & introgress **HMWG-17+18**
- ***Glu-D1***: Introgress **HMWG-5+10** or **HMWG 2+12** from stocks with the *Glu-D1* locus translocated onto chromosome 1AL of durum





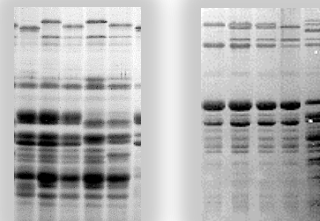
# Durum Wheat for Industrial Bread-Making

## Development of HMWG-diversified durum germplasm

**Donor HMWG-5+10:** Line from **Adam Lukasevski** (UC Riverside), carrying the *Glu-D1* locus with the 5+10 allele translocated onto 1AL

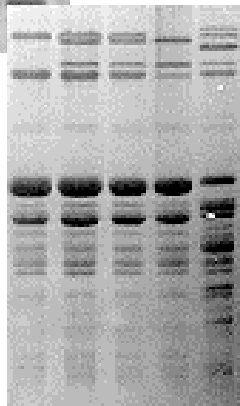
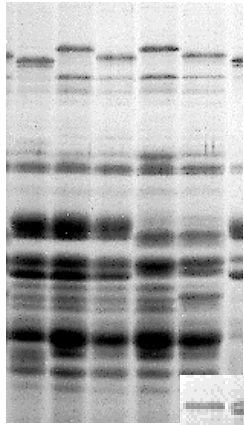
**Donor HMWG-17+18, 1, 2\*:** F<sub>2</sub> plant from cross between PAVON translocation line (*A. Lukasevski*, UC Riverside) and OPATA, top-crossed to the donor of HMWG-5+10

- ▶ **Cross donor of “Novel” or non-endogenous to 5 CIMMYT elite lines**
  - All LR/YR resistant, high yield potential at the time and variable quality characteristics
  - Designated as RP or Recurrent Parent
- ▶ **Backcrossing to RP**
  - Selection for different HMWG combinations using SSR marker for HMWG-5+10 and SDS-PAGE profile on bulk seed from BCF<sub>1</sub> plants
  - Stopped at **BC<sub>5</sub>**
- ▶ **Self BC<sub>5</sub> progenies and selection (pedigree)**
  - Selection for different HMWG combinations using SDS-PAGE profile on bulk seed from single plants or ½ kernels, confirmation with SNP markers for *Glu-A1*, *Glu-B1* and *Glu-D1* alleles
  - Selection for agronomic type
  - Stopped at **BC<sub>5</sub>F<sub>9</sub>**



# Evaluation of HMWG-Diversified Durum Germplasm

*Germplasm tested in yield trial*



Allele at Glu-A1	Allele at Glu-B1	CIMMYT	CIMMYT	CIMMYT	CIMMYT	CIMMYT	UC Davis	UC Davis	Total HMWG Combination
		Rec.Par. 1 null / 7+8	Rec.Par. 2 null / 7+8	Rec.Par. 3 null / 7+17	Rec.Par. 4 null / 7+17	Rec.Par. 5 null / 7+8	Rec.Par. 6 null / 6+8	Rec.Par. 7 null / 7+8	
Null	17+18	.	2	2	2	.	.	.	6
Null	6+8	2	2	.	2	2	.	.	8
Null	7+17	.	.	2	2	.	.	.	4
Null	7+8	1	2	.	.	2	.	.	5
1	17+18	.	.	.	.	.	.	.	.
1	6+8	.	2	.	.	.	.	.	2
1	7+17	.	.	2	.	.	.	.	2
1	7+8	.	2	2	.	.	.	.	4
2*	17+18	.	3	2	1	.	.	.	6
2*	6+8	.	.	.	.	.	.	.	.
2*	7+17	.	.	2	2	.	.	.	4
2*	7+8	.	2	.	.	.	.	.	2
5+10	17+18	.	2	1	1	.	.	.	4
5+10	6+8	2	2	.	1	2	.	.	7
5+10	7+17	.	.	3	2	.	.	.	5
5+10	7+8	.	2	.	1	.	.	.	3
2+12	6+8	.	.	.	.	.	1	.	1
2+12	7+8	.	.	.	.	.	.	1	1
Total Rec. Par.		5	21	16	14	6	1	1	64
Null	6+8	Durum KOFA							
Null	7+8	Durum Check JUPARE C2001							
2*	17+18	Bread Wheat Check TACUPETO F2001 (with HMWG-5+10 in <i>Glu-D1</i> )							
2*	7+9	Bread Wheat Check KRONSTAD F2004 (with HMWG-5+10 in <i>Glu-D1</i> )							

## ► CIMMYT isogenic lines:

- 62 BC<sub>5</sub>F<sub>12</sub> lines in 5 elite backgrounds (RP) with variable novel or endogenous HMWG combinations
- 5 recurrent parents

## ► UC Davis isogenic lines:

- 2 HMWG-2+12 provided by Jorge Dubcovsky
- 2 recurrent parents

## ► 4 Checks:

- 2 Durum wheat
- 2 Bread wheat



# Evaluation of HMWG-Diversified Durum Germplasm

*Yield trial conditions*



## ► Field Trial in CENEB-Obregon 2017

- 75 genotypes in 2-reps RCBD
- Plots: 4 rows of 4.8 m (7.68 m<sup>2</sup>)
- Full irrigation & optimal fertilization
- Preventive fungicide protection
- 3 kg per plot clean grain provided to quality lab for comprehensive quality evaluation





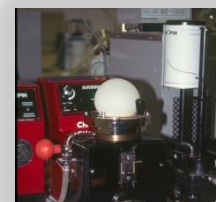
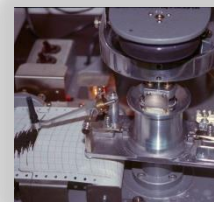
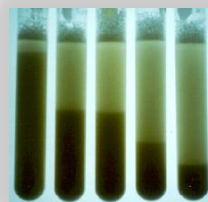
# Evaluation of HMWG-Diversified Durum Germplasm

## *Traits measured*



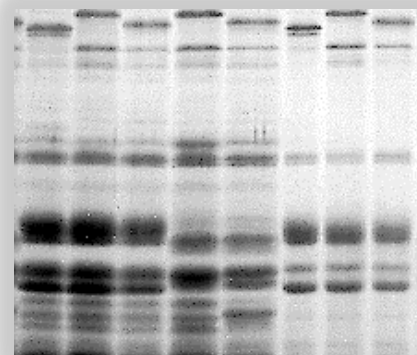
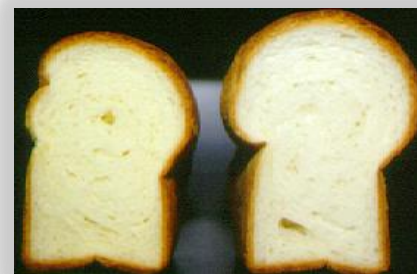
### ► Agronomic Traits

- Heading & maturity
- Plant Height
- Grain yield



### ► Quality Traits

- 1000 Kernel Weight, Test weight
- Kernel Characteristics (image analysis, SKCS)
- Grain Protein Content (NIR, 12.5% m.b.), Flour Protein Content (NIR, 14% m.b.)
- SDS-Sedimentation Volume (1 gr. ground wheat + flour)
- Sedimentation Index: Volume/GPC
- Yellow color (b-value, colorimeter, ground wheat + flour)
- Milling Yield
- Alveograph on flour (W, P/L)
- Mixograph on flour
- Bread making properties (Loaf volume + Bread Crumb Appearance)
- SDS-PAGE glutenin profile (High & Low Molecular Weight Glutenin Sub-Units)



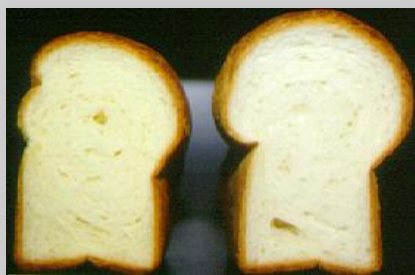
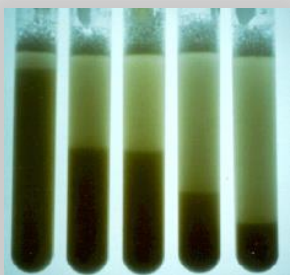


# Evaluation of HMWG-Diversified Durum Germplasm

## Important correlations

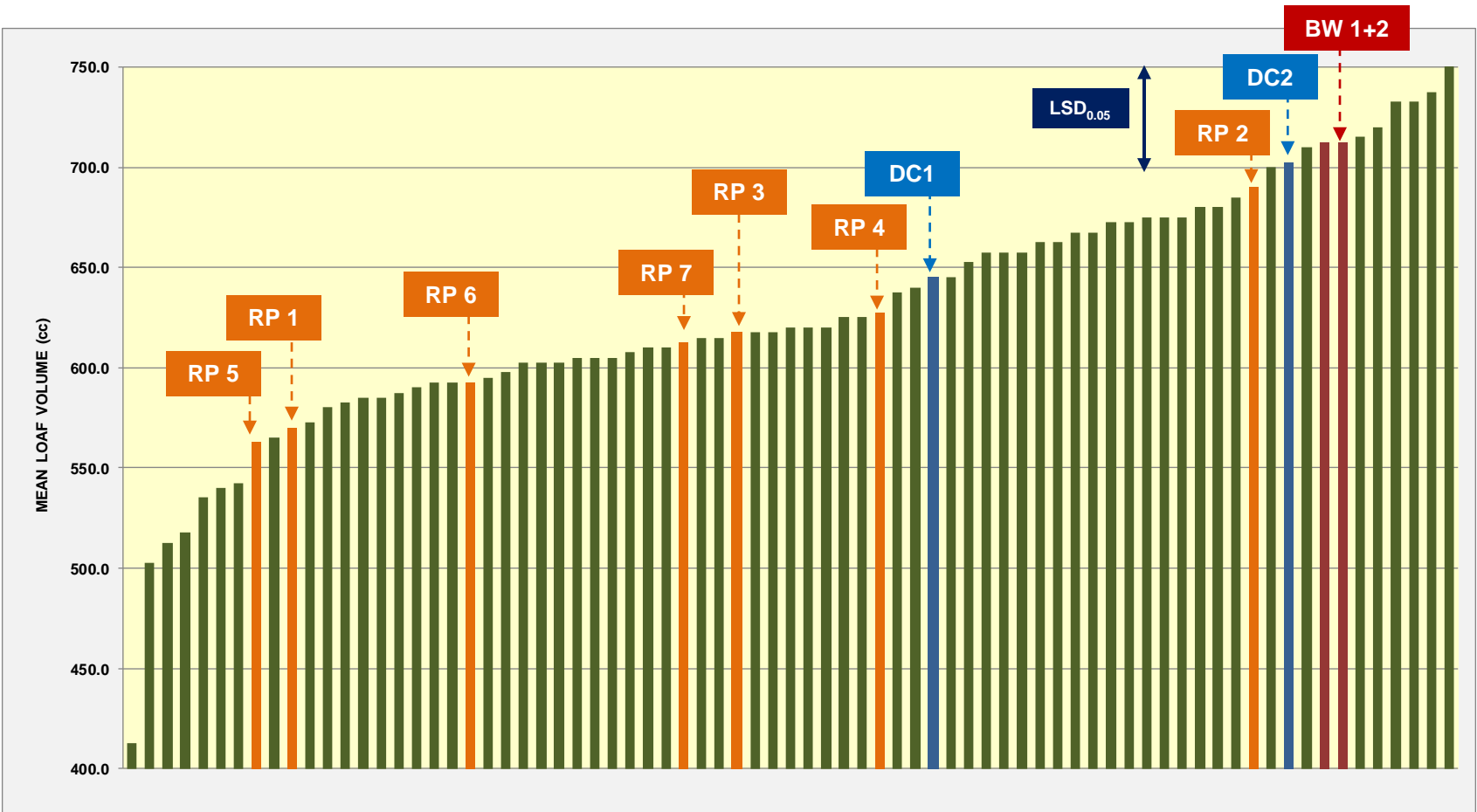
- Extensibility most critical to loaf volume
  - Protein quantity still a factor
  - Strength still needed
  - Short mixing time a plus

	Loaf Volume	Alveograph W	Alveograph P/L	Flour Sedimentation
Grain Protein	0.47	0.49	-0.17 <sup>NS</sup>	0.45
Flour Protein	0.55	0.53	-0.21 <sup>NS</sup>	0.49
Grain Sedimentation Volume	0.36	0.53	-0.20 <sup>NS</sup>	0.88
Flour Sedimentation Volume	0.38	0.57	-0.19 <sup>NS</sup>	.
Mixogram Mixing Time	-0.38	0.00 <sup>NS</sup>	0.75	0.52
Mixogram Peak	-0.36	0.03 <sup>NS</sup>	0.75	0.54
Alveograph W	0.46	.	0.02 <sup>NS</sup>	0.57
Alveograph P/L	-0.62	0.02 <sup>NS</sup>	.	0.19 <sup>NS</sup>



# Evaluation of HMWG-Diversified Durum Germplasm

*Phenotypic distribution - LOAF VOLUME*

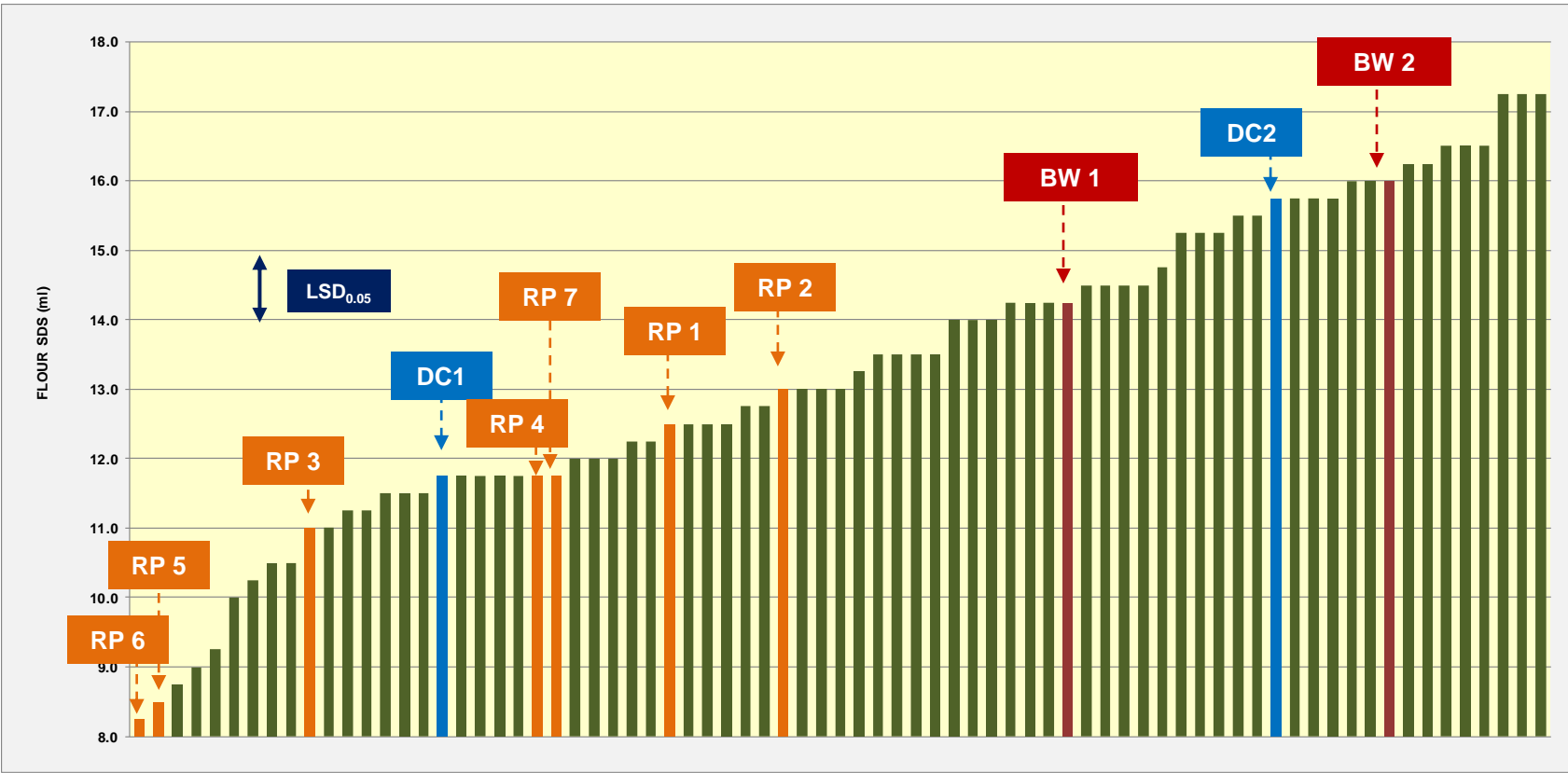


- RP** Recurrent Parent used as background
- DC** Durum Check: 1 = JUPARE C2001, 2 = KOFA
- BW** Bread Wheat Check: 1 = TACUPETO F2001, 2 = KRONSTAD F2004
- Isogenic line with varying HMWG composition



# Evaluation of HMWG-Diversified Durum Germplasm

*Phenotypic Distribution – FLOUR SDS*

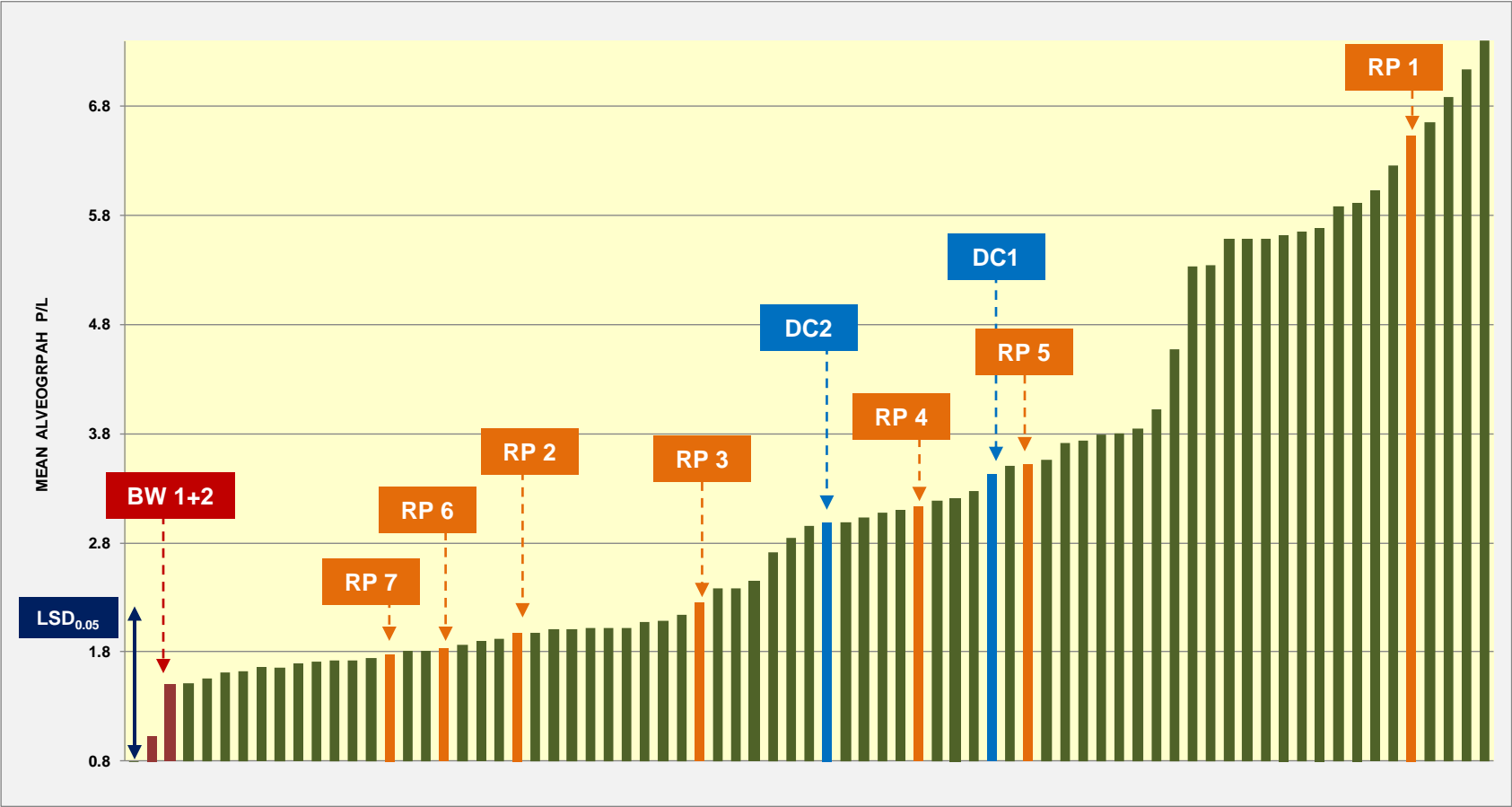


- RP** Recurrent Parent used as background
- DC** Durum Check: 1 = JUPARE C2001, 2 = KOFA
- Isogenic line with varying HMWG composition**
- BW** Bread Wheat Check: 1 = TACUPETO F2001, 2 = KRONSTAD F2004



# Evaluation of HMWG-Diversified Durum Germplasm

*Phenotypic distribution – ALVEOGRAPH P/L*



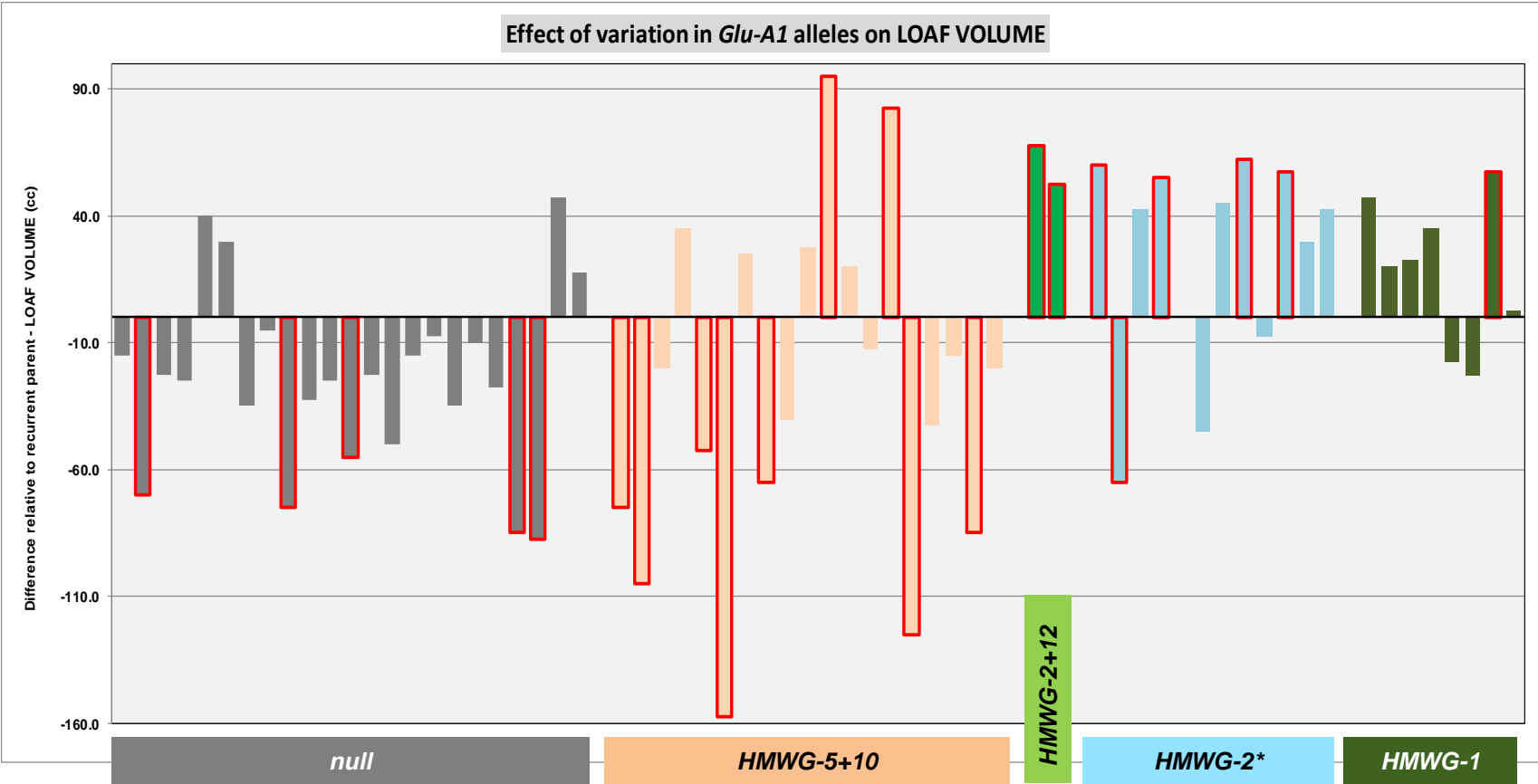
- RP** Recurrent Parent used as background
- DC** Durum Check: 1 = JUPARE C2001, 2 = KOFA
- BW** Bread Wheat Check: 1 = TACUPETO F2001, 2 = KRONSTAD F2004
- Isogenic line with varying HMWG composition





# Evaluation of HMWG-Diversified Durum Germplasm

Effect of variation at *Glu-A1* - LOAF VOLUME

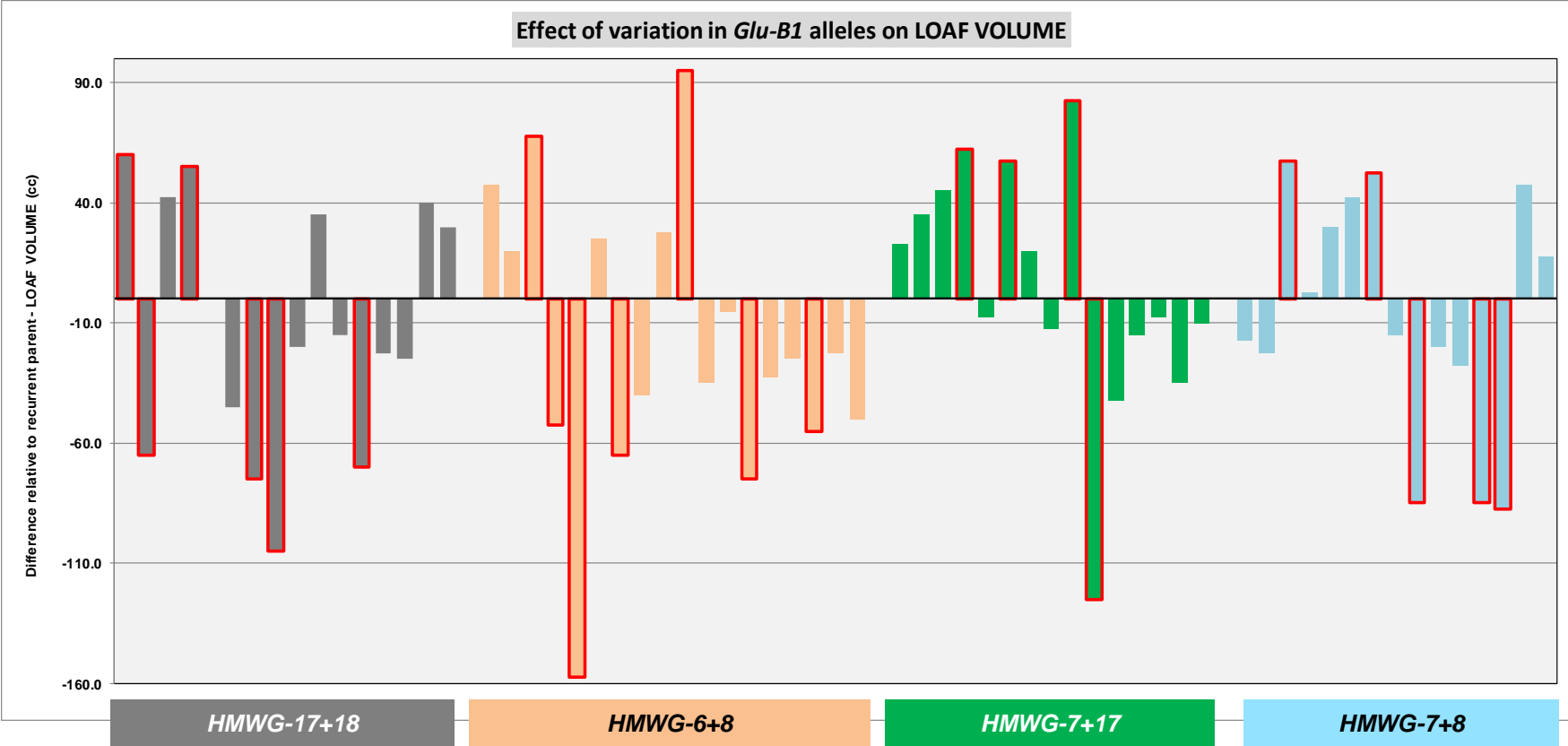


Bars with red border represent differences that are statistically significant



# Evaluation of HMWG-Diversified Durum Germplasm

Effect of variation at *Glu-B1* - LOAF VOLUME

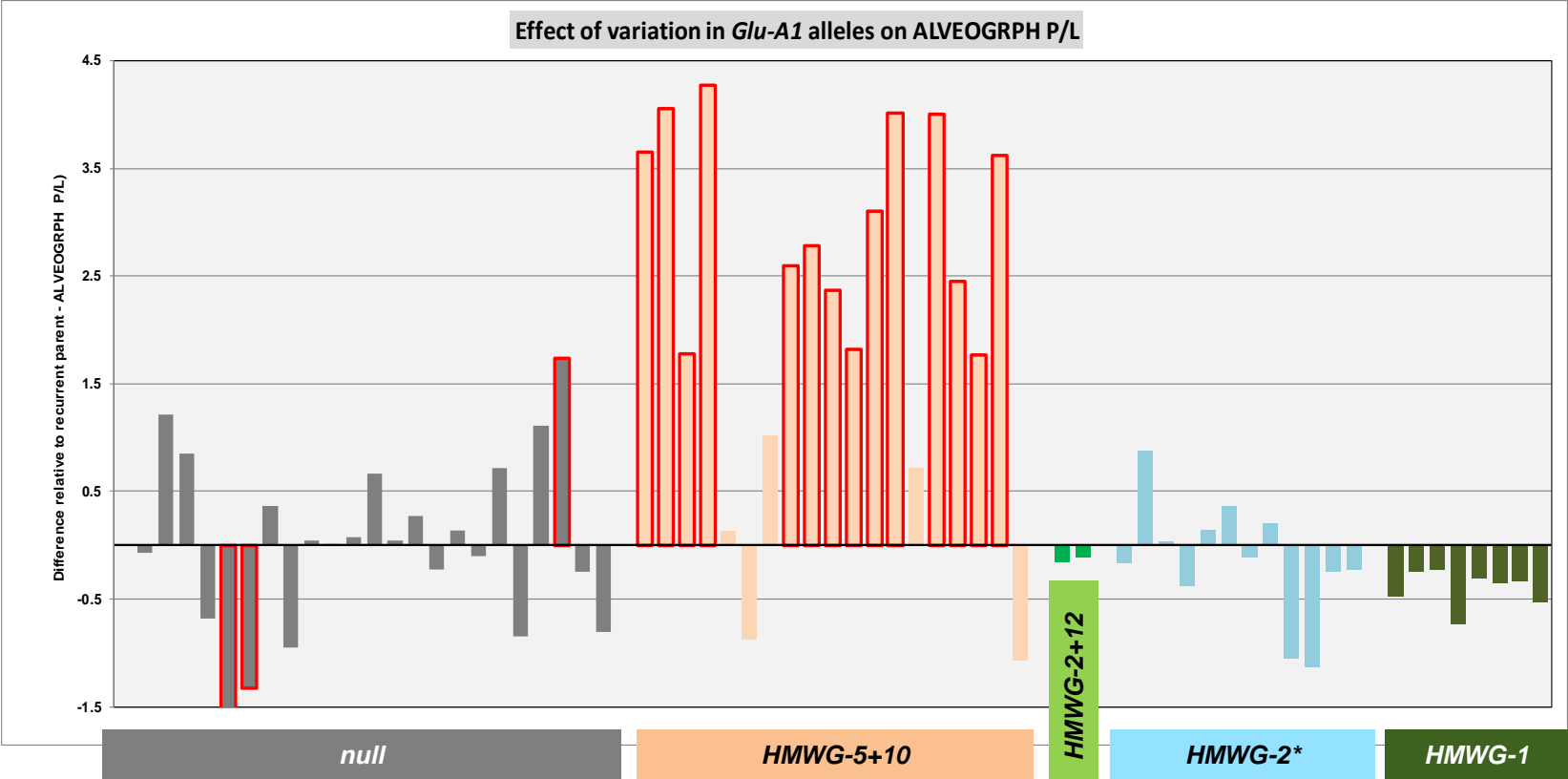


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# Evaluation of HMWG-Diversified Durum Germplasm

Effect of variation at *Glu-A1* – *ALVEOGRPH* P/L

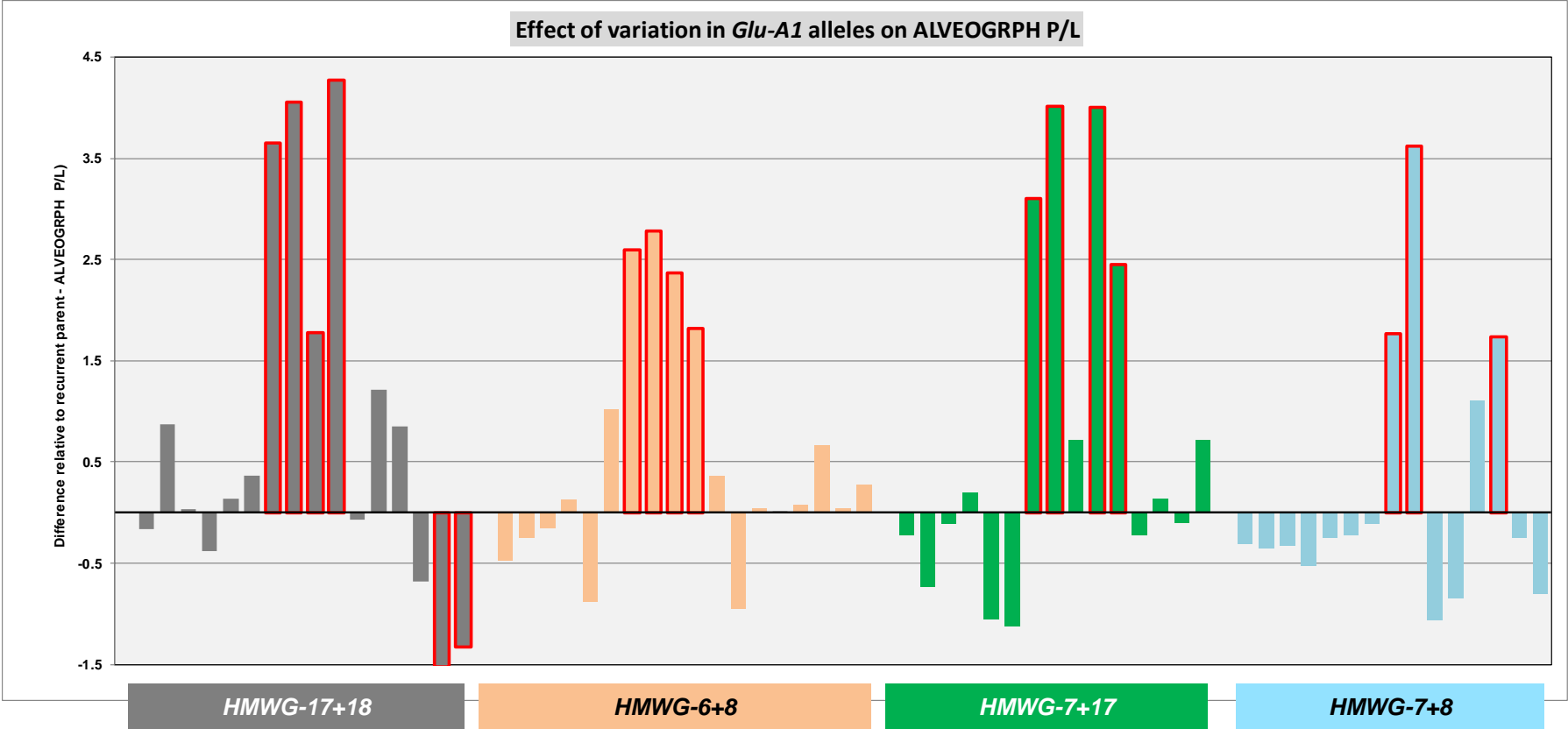


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# Evaluation of HMWG-Diversified Durum Germplasm

Effect of variation at *Glu-B1* – *ALVEOGRPH* P/L



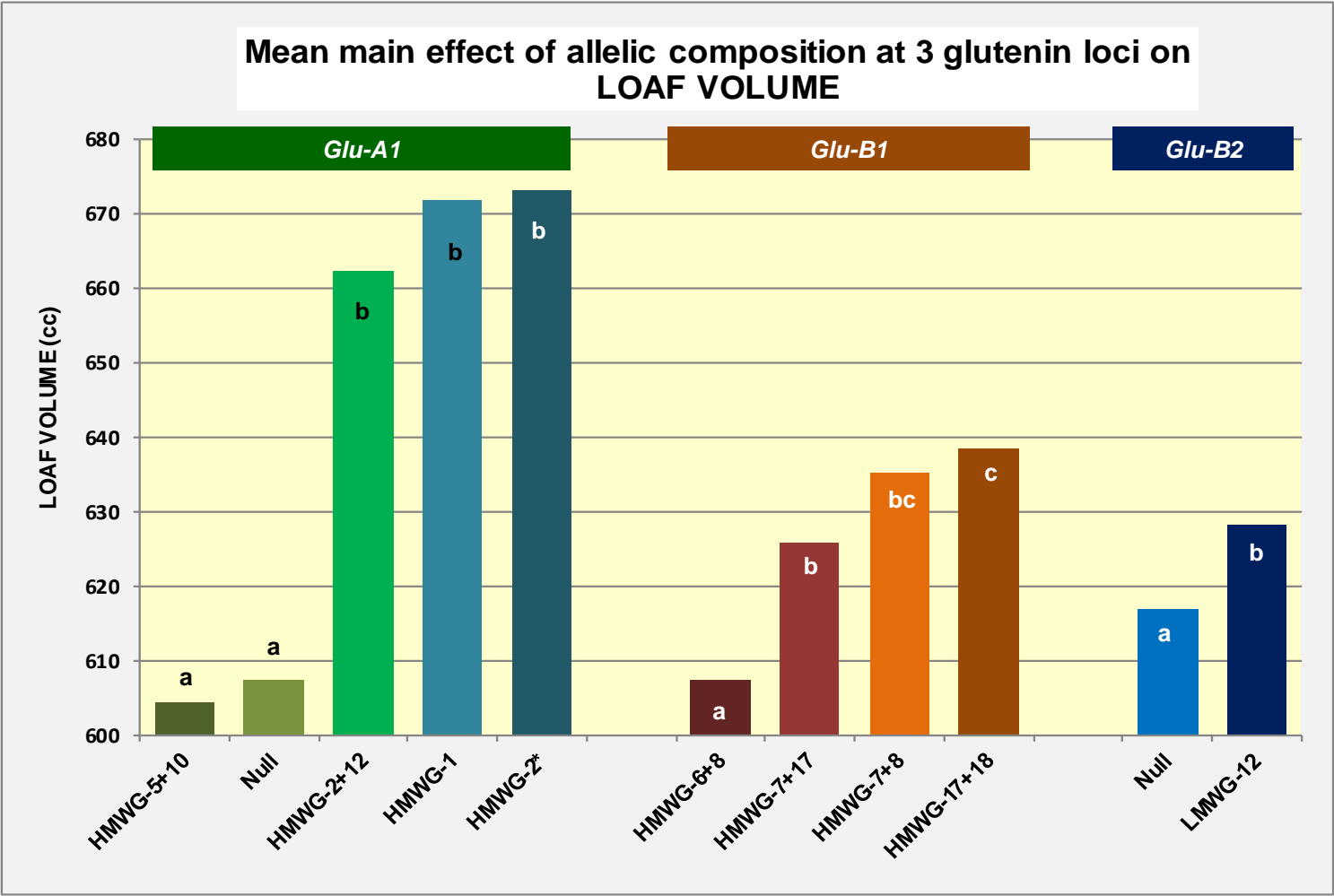
Bars with red border represent differences that are statistically significant





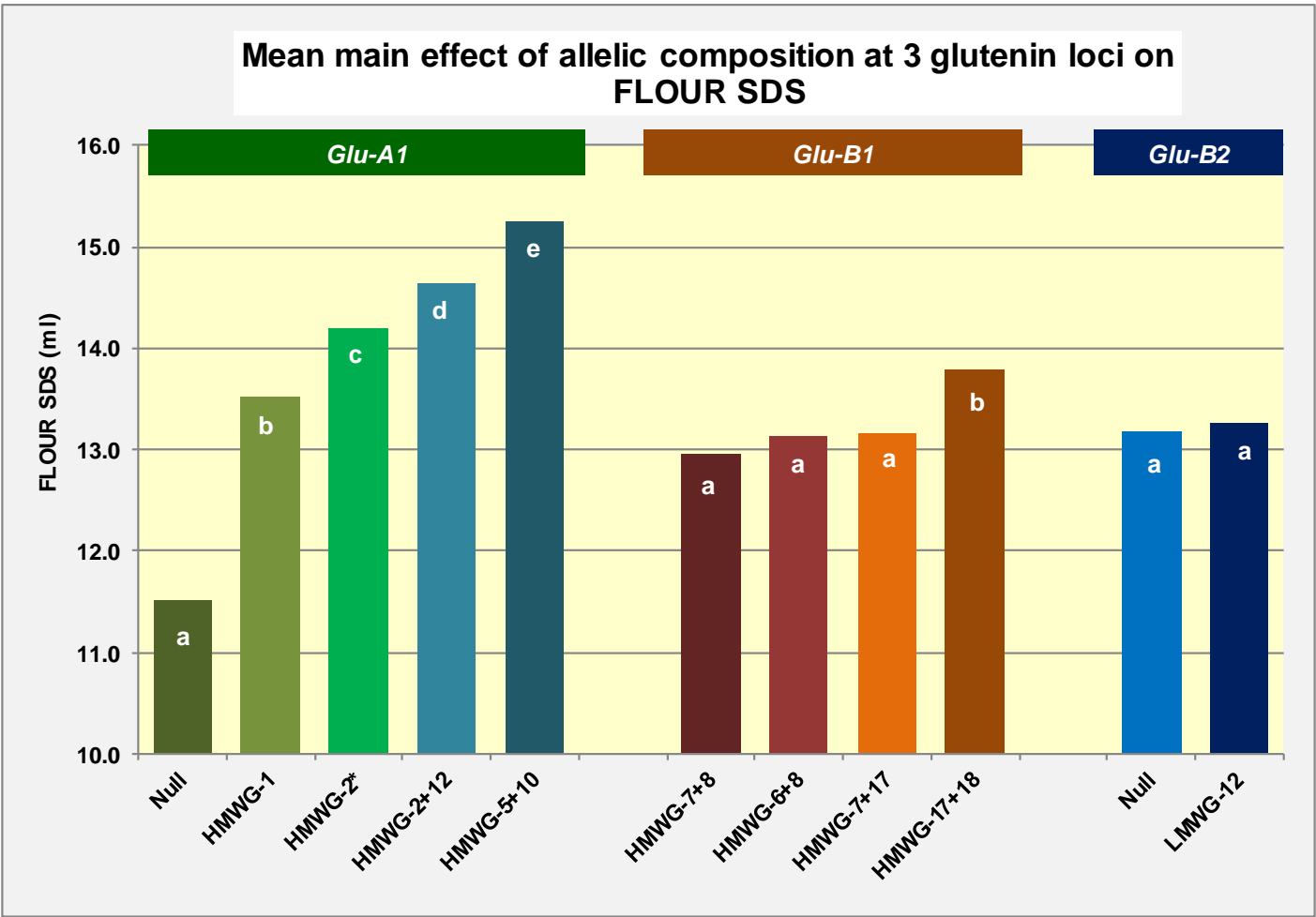
# Evaluation of HMWG-Diversified Durum Germplasm

*Glutenin loci main effects - LOAF VOLUME*



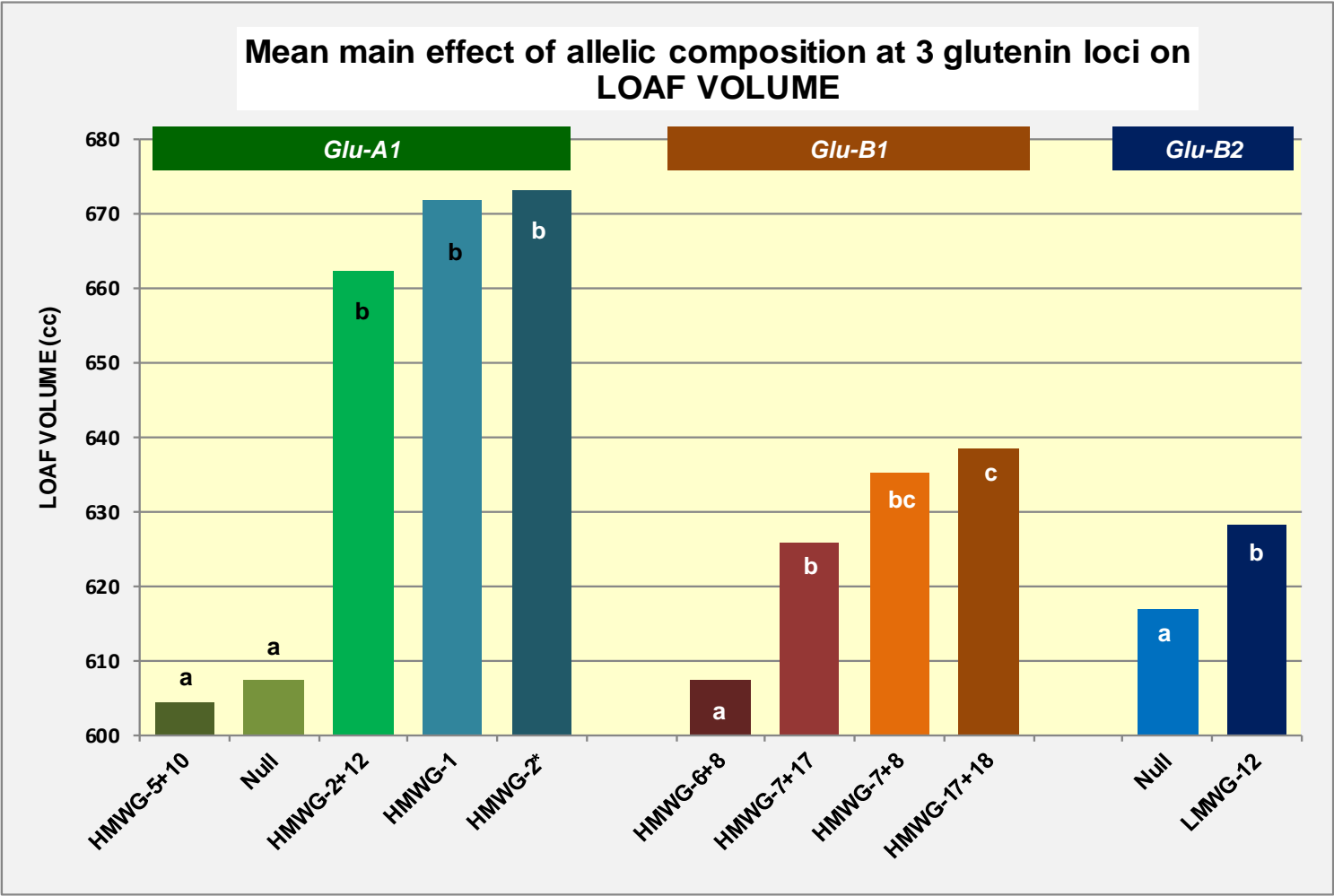
# Evaluation of HMWG-Diversified Durum Germplasm

*Glutenin loci main effects – FLOUR SDS*



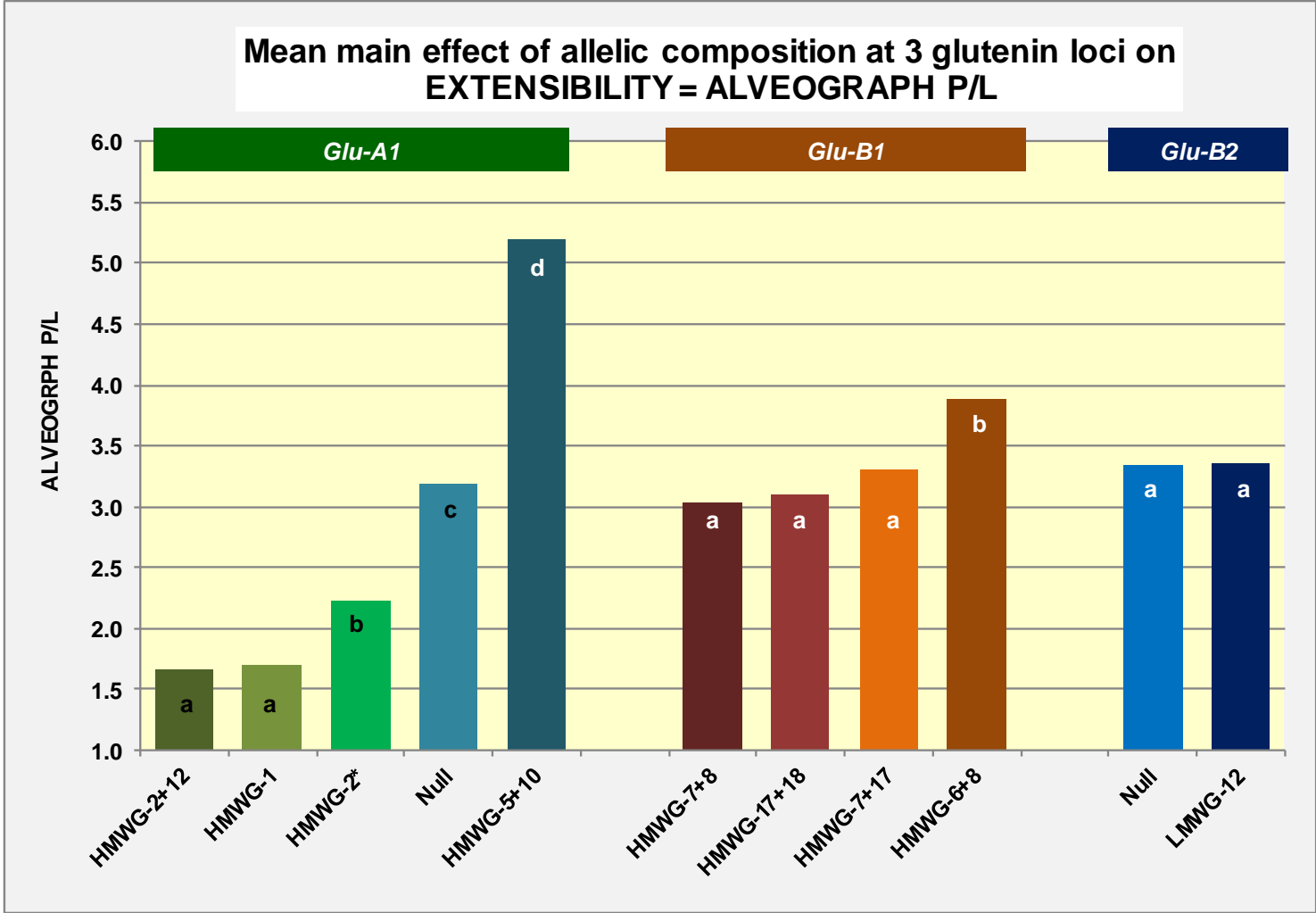
# Evaluation of HMWG-Diversified Durum Germplasm

*Glutenin loci main effects - LOAF VOLUME*



# Evaluation of HMWG-Diversified Durum Germplasm

*Glutenin loci main effects – ALVEOGRAPH P/L*





# Conclusions I

## *Preliminary effects of non-durum glutenin*

- ▶ **Durum baking characteristics still typical with these combinations**
  - Limited mostly by lack of extensibility
  - Affected less by strength and more by protein content , even less when measured by sedimentation
  
- ▶ **Some durum had loaf volume not significantly lower than the bread wheat checks**
  - Some numerically higher
  - Were among the most extensible
  - Generally carried either HMWG-1 or HMWG-2\*
  
- ▶ **SDS-sedimentation provided an erroneous indication of baking potential**
  - Not closely enough associated with loaf volume
  - HMWG-5+10 were the highest in sedimentation volume but the lowest in loaf volume



# Conclusions II

## *Preliminary effects of non-durum glutenin*

### ► **Allelic composition at Glu-A1:**

- Surprisingly, HMWG-5+10 was associated with the worst loaf volume due to its very high tenacity.
- The best results were associated with the presence of HMWG-1, HMWG-2\* and HMWG-2+12

### ► **Allelic composition at Glu-B1:**

- Most were equivalent, except for HMWG-6+8 which tended to yield lower loaf volumes

### ► **If/once confirmed these results could help in guiding:**

- Strategy to improve bread-making quality of durum wheat
- Target this newly created variability towards specific end-use products or processes:



**BILL &  
MELINDA  
GATES  
foundation**

**“Delivering Genetics  
Gains in Wheat”**

**DFID** Department for  
International  
Development

# Funding & Support for Durum Wheat Breeding at CIMMYT – 2017-18



**India**

**Sonora - Mexico**



**Spain**



**Australia**



**Canada - Saskatchewan**



**CIMMYT – coordinated initiatives**



**CRP - WHEAT**



**Foundations:**





**Thank You...**  
**... Any questions?**