



▲ SUNDAY JULY 21 ()

Welcome Reception

Location: TCU Place (<https://tcuplace.com/>)

Time: 6:30 pm – 8:30 pm

▲ MONDAY JULY 22 ()

08:50-09:30

OPENING CEREMONY

Salon ABCD

Chair: Curtis Pozniak (Canada)

09:30-10:20

PLENARY LECTURE

CREATING A SUSTAINABLE FOOD FUTURE: WHAT IS THE ROLE OF CROP BREEDING?

Timothy D. Searchinger, Senior Fellow, World Resources Institute

Salon ABCD

Chair: Hermann Buerstmayr (Austria)

10:20-10:50

HARNESSING THE POWER OF PARTNERSHIPS FOR GLOBAL WHEAT RESEARCH AND FOOD SECURITY

M. Kropff, Director General, CIMMYT, Global Wheat Program

Salon ABCD

Chair: Hermann Buerstmayr (Austria)

10:50-11:20

COFFEE BREAK



Session 1: Protecting Yield: Resistance to Abiotic Stresses
Salon ABCD

Chairs: D. Brian Fowler (Canada) and Fernanda Dreccer (Australia)

11:20-11:50
PLENARY – GENOMIC DISSECTION OF ABIOTIC STRESSES
Salon ABCD
J. Tibbits (Australia)

11:50-12:10
**MAPPING THE HIGH TEMPERATURE-REGULATED WHEAT PHOSPHOPROTEOME AS A
SOURCE FOR NOVEL BREEDING MARKERS**
Salon ABCD
I. De Smet (Belgium)

12:10-12:30
**GENETIC DISSECTION OF DURUM WHEAT ROOT SYSTEM AND CANOPY MORPHOLOGICAL
TRAITS BY MEAN OF HIGH-THROUGHPUT PHENOTYPING PLATFORM**
Salon ABCD
G. Sciara (Italy) (S)

12:30-12:50
**EVALUATION AND
ASSOCIATION MAPPING OF A COMBINED HEAT-SALINITY STRESS TOLERANCE IN A
WHEAT MULTIPLE SYNTHETIC DERIVATIVES POPULATION**
Salon ABCD
Y. Gorafi (Japan)

12:50-13:50
LUNCH

13:50-14:10
**POSITIONAL CLONING OF A LOCUS INCREASING BIOMASS AND YIELD IN WHEAT IN HOT
CONDITIONS**
Salon ABCD
P. Tricker (Australia)

14:10-14:30
THE HEAT AND DROUGHT WHEAT IMPROVEMENT CONSORTIUM (HEDWIC)
Salon ABCD
M. Reynolds (Mexico)

14:30-14:50
**APPLICATION OF NEXT-GENERATION GENOMICS AND PHENOMICS TOOLS TO IDENTIFY
CANDIDATE GENES FOR WINTER-SURVIVAL IN WINTER WHEAT**
Salon ABCD
Y. Chen (Canada) (S)



14:50-15:10

FROST DAMAGE ON GRAIN NUMBER IN WHEAT AT DIFFERENT SPIKE DEVELOPMENTAL STAGES AND ITS MODELLING

Salon ABCD

DL. Martino (Argentina) (S)

15:10-15:40

COFFEE BREAK

Session 2: Wheat Safety, Nutrition and Human Health

Salon ABCD

Chair: Valerie Lullien-Pellerin (France)

15:40-16:10

PLENARY – PROGRESS OF THE INTERNATIONAL COLLABORATION FOR ENHANCING WHEAT QUALITY FOR PROCESSING AND HEALTH

Salon ABCD

TM. Ikeda (Japan) (S)

16:10-16:30

ASPARAGINE CONTENT OF CANADIAN WHEAT: COUNTERACTING A COMMERCIAL THREAT

Salon ABCD

S. Khorshidi (Canada)

16:30-16:50

CHARACTERIZATION OF BIOFORTIFIED HARVESTPLUS WHEAT GENOTYPES FOR ROOT UPTAKE, SHOOT TRANSLOCATION, FOLIAR ABSORPTION, RE-MOBILIZATION AND SEED DEPOSITION OF ZN

Salon ABCD

R. Rehman (Turkey) (S)

16:50-17:10

TAILORING NON-IMMUNOGENIC WHEAT GENOTYPES FOR GLUTEN-SENSITIVE INDIVIDUALS

Salon ABCD

S. Rustgi (USA)

18:00-20:00

REMAI MODERN EVENING NETWORKING RECEPTION

Remai Modern Museum

08:30-09:10
PLENARY LECTURE
PLANT GENETICS AND THE FUTURE OF FOOD
Salon ABCD

Dr. Pamela Ronald, Distinguished Professor, Department of Plant Pathology and the Genome Center at the University of California, Davis

Chair: Cristobal Uauy (UK)

Concurrent Session 3A: Wheat Diversity and Evolution
Salon ABCD

Chairs: Hisashi Tsujimoto (Japan) and Julie King (UK)

Concurrent Session 3B: Wheat End-Use Functionality
Centennial Hall A/B

Chairs: Carlos Guzman (Mexico) and Craig Morris (USA)

09:10-9:40
PLENARY – WHEAT DOMESTICATION IN LIGHT OF HAPLOTYPE ANALYSES OF THE BRITTLE RACHIS 1 GENES (BTR1-A AND BTR1-B)
Salon ABCD
A. Distelfeld (Israel)

09:10-9:40
PLENARY – EXPLOITING GENETIC DIVERSITY TO IMPROVE FIBRE AND OTHER BIOACTIVE COMPONENTS
Centennial Hall A/B
A. Lovegrove (UK)

9:40-10:00
EXOME SEQUENCING HIGHLIGHTS THE ROLE OF HISTORIC WILD RELATIVE INTROGRESSION IN BROADENING THE ADAPTIVE POTENTIAL OF MODERN BREAD WHEAT
Salon ABCD
E. Akhunov (USA)

9:40-10:00
DIVERSIFICATION OF DURUM WHEAT INDUSTRIAL END-USES THROUGH THE GENETIC MODIFICATION OF ITS GLUTENIN COMPOSITION AND GRAIN TEXTURE
Centennial Hall A/B
K. Ammar (Mexico)

10:00-10:20
CHROMOSOME ENGINEERING OF WHEAT-AGROPYRON CRISTATUM AND GENE MINING OF THE NOVEL GERMPLASM
Salon ABCD
WH. Liu (China)

10:00-10:20
WHAT'S XAT? MOVING A GENE FROM THE D GENOME TO THE A GENOME
Centennial Hall A/B
DE. Mather (Australia)

10:20-10:40
ANALYSIS OF THE RECOMBINATION LANDSCAPE OF HEXAPLOID BREAD WHEAT REVEALS GENES CONTROLLING RECOMBINATION AND GENE CONVERSION FREQUENCY
Salon ABCD
A. Hall (UK)

10:20-10:40
DATA INTEGRATION TO IDENTIFY KEY METABOLIC PROTEINS INVOLVED IN WHEAT STORAGE PROTEIN SYNTHESIS
Centennial Hall A/B
C. Ravel (France)

10:40-11:10
COFFEE BREAK



11:10-11:30

**CANADIAN WHEAT – NAM: A POWERFUL
RESOURCE**

Salon ABCD
W. Zhang (Canada)

11:10-11:30

**GLUTENIN SUBUNIT COMPOSITION AND
AMINO ACID DEPOSITION OF LANDRACES
AND MODERN DURUM WHEAT CULTIVARS
WITH CONTRASTING GLUTEN**

Centennial Hall A/B
AR. Schwember (Chile)

11:30-11:50

**IMPROVING FLORET FERTILITY THROUGH
THE MUTATION OF A HOMEBOX GENE
DURING WHEAT EVOLUTION UNDER
DOMESTICATION**

Salon ABCD
S Sakuma (Japan)

11:30-11:50

**UNVEILING THE IMPACT OF PROTEIN
QUANTITY AND QUALITY ON TEXTURAL
PROPERTIES**

Centennial Hall A/B
K. Wang (Canada)

11:50-12:10

**SELECTION SIGNATURES IN CIMMYT'S
INTERNATIONAL ELITE SPRING AND SEMI-
ARID WHEAT YIELD TRIALS**

Salon ABCD
A. Mondaini (Germany) (S)

11:50-12:10

**WHEAT QUALITY: THE IMPACT OF GENOTYPE,
ENVIRONMENT, AND PROCESSING ON
FUNCTIONALITY AND NUTRITION IN VARIOUS
APPLICATIONS**

Centennial Hall A/B
E. Johansson (Sweden)

12:10-12:30

**SVEVO DURUM WHEAT GENOME SEQUENCE
AS A FRAMEWORK TO INVESTIGATE
TETRAPLOID WHEAT (TRITICUM TURGIDUM
SSPS.) EVOLUTION AND DIVERSITY**

Salon ABCD
M. Maccaferri (Italy)

12:10-12:30

**MOLECULAR MARKER DEVELOPMENT AND
APPLICATION FOR IMPROVING QUALITIES IN
BREAD WHEAT**

Centennial Hall A/B
ZH. He (China)

12:30-13:30

LUNCH

13:30-13:50

**GERMPLASM EXCHANGE UNDER THE
CONVENTION FOR BIOLOGICAL DIVERSITY:
IMPLICATIONS FOR WHEAT RESEARCH**

Salon ABCD
W. Coffman (USA)

13:30-13:50

**VARIABILITY IN MONO- AND POLYMERIC
PROTEINS IN A WORLDWIDE COLLECTION OF
COMMERCIAL DURUM WHEAT CULTIVARS
AND CORRELATIONS WITH ALVEOGRAPH W
AND P/L**

Centennial Hall A/B
B. Toth (South Africa)

13:50-14:10

**WILD EMMER WHEAT ALLELES PROMOTE
DROUGHT ADAPTATION MECHANISMS FOR
CHANGING CLIMATE**

Salon ABCD
H. Bacher (Israel) (S)

13:50-14:10

**DEVELOPMENT OF CAROTENOID PIGMENT
ENRICHED BREAD WHEAT THROUGH
MARKER ASSISTED SELECTION**

Centennial Hall A/B
A. Sharma (India)

PRESENTATION CANCELLED



14:10-16:00
POSTER SESSION

(POSTERS WILL BE DISPLAYED ALL WEEK)

Themes presented:

- *Wheat Diversity, Evolution, and Genetic Resources*
- *Protecting Yield: Resistance to Biotic and Abiotic Stresses*
- *Wheat Uses: Functionality, Nutrition, Safety and Human Health*

Session 4: Wheat Genetic Resources
Salon ABCD

Chairs: Sylvie Cloutier (Canada) and Alison Bentley (UK)

16:00-16:30

**PLENARY – EVIDENCE FOR THE VALUE OF SYNTHETIC, LANDRACE AND INTROGRESSION TO
IMPROVE ADAPTATION TO HEAT STRESS: NEW INSIGHTS RELATED WITH NIGHT
TRANSPIRATION**

Salon ABCD
G. Molero (Mexico)

16:30-16:50

**GENETIC RESOURCES FOR SPRING WHEAT BREEDING IN SIBERIA: SYNTHETICS, NORTH
AMERICAN VARIETIES, KASIB NETWORK MATERIAL**

Salon ABCD
V. Shamanin (Russian Federation)

16:50-17:10

INTRODUCING NEW GENETIC DIVERSITY INTO WHEAT

Salon ABCD
J. King (UK)

17:10-17:30

OZWHEAT: A NEW PLATFORM FOR ASSOCIATION GENETICS AND MARKER DEVELOPMENT

Salon ABCD
J. Hyles (Australia) (S)

17:30-17:50

**GOBII TRANSFORMING BREEDING THROUGH INTEGRATED DATA MANAGEMENT AND
GENOMIC-ASSISTED SELECTION**

Salon ABCD
Y. Gao (USA)

17:50-18:50

WHEAT INITIATIVE GENERAL ASSEMBLY

Chairs: Peter Langridge and Frank Ordon (Wheat Initiative, Germany)

Session 5: Wheat Breeding and Enabling Technologies
Salon ABCD

Chairs: Richard Cuthbert (Canada) and Gina Brown-Guedira (USA)

08:40-09:10

**PLENARY – SPRING BREAD WHEAT BREEDING AT ICARDA: PROGRESS FOR YIELD,
DROUGHT AND HEAT TOLERANCE TARGETING CWANA AND SSA REGIONS**

Salon ABCD

W. Tadesse (Morocco)

09:10-09:30

**ON THE HOLISTIC INTEGRATION OF GENOMIC SELECTION WITHIN A COMMERCIAL WHEAT
BREEDING PROGRAMME**

Salon ABCD

A. Norman (Australia)

09:30-09:50

**BREAD-MAKING QUALITY PREDICTIONS: OPTIMIZATION OF MULTI-TRAIT ASSISTED GENOMIC
SELECTION**

Salon ABCD

S. Ben Sadoun (France) (S)

09:50-10:10

PROSPECTS OF HYBRID WHEAT BREEDING FOR A SUSTAINABLE AGRICULTURE

Salon ABCD

P. Thorwarth (Germany)

10:10-10:30

**ENABLING NEW WHEAT BREEDING SCHEMES – MERGING DOMINANT MALE STERILITY AND
MARKER TECHNOLOGY**

Salon ABCD

M. Gutierri (USA)

10:30-11:00

COFFEE BREAK

11:00-11:20

**HOW PPD-1 GENES AFFECT PHENOLOGY AND YIELD FORMATION OF DURUM WHEAT UNDER
CONTRASTING LATITUDES**

Salon ABCD

D. Villegas (Spain)

11:20-11:40

DELAYING OR DELIVERING? UNDERSTANDING WHEAT SENESCENCE

Salon ABCD

EA. Chapman (UK) (S)

11:40-12:00

ARE IHT (INCREASED HEIGHT), NOT RHT (REDUCED HEIGHT), GENES IMPORTANT TO DEFINE BETTER WHEAT ADAPTATION TO EXTREME ENVIRONMENTS WITH CONSTANT DROUGHT AND HEAT?

Salon ABCD

K. Yermekbayev (Kazakhstan) (S)

12:00-12:20

THE BREEDER'S EXEMPTION AND ITS ECONOMIC AND ENVIRONMENTAL IMPACTS ON WINTER WHEAT PRODUCTION IN GERMANY

Salon ABCD

S. Lüttringhaus (Germany) (S)

12:20-12:40

ALLELIC DIVERSITY STUDY OF FUNCTIONAL GENES IN EAST AFRICA BREAD WHEAT GERMPLASM HIGHLIGHTS OPPORTUNITIES FOR GENETIC IMPROVEMENT

Salon ABCD

O. Shorinola (Africa)

12:40-13:40

LUNCH

Session 5: Wheat Breeding and Enabling Technologies

Salon ABCD

Chairs: Silvia Rosa (Canada) and Alex Morgounov (Turkey)

13:40-14:00

UAV-BASED HIGH-THROUGHPUT PHENOTYPING FOR WHEAT BREEDING AND PHYSIOLOGICAL PRE-BREEDING

Salon ABCD

F. Pinto (Mexico)

14:00-14:20

THE USE OF MAGIC AND NAM POPULATIONS IN WHEAT PRE-BREEDING

Salon ABCD

PS. Sarup (Denmark)

14:20-14:40
CRISPR-BASED PRECISION BREEDING IN WHEAT
Salon ABCD

E. Akhunov (USA)

14:40-15:00
CHALLENGES OF TRAIT COMPLEXES IN SPRING WHEAT BREEDING
Salon ABCD

S. Berraies (Canada)

15:00-22:00
KERNEN FARM TOUR AND DINNER
Kernen Farm

▲ **THURSDAY JULY 25 ()**

08:30-09:00
**PLENARY – MULTIPLE HIGH QUALITY WHEAT GENOME ASSEMBLIES REVEAL EXTENSIVE
VARIATION IN THE PAN-GENOME OF ELITE CULTIVARS**

Salon ABCD
N. Stein (Germany, Canada)

Chairs: Zhonghu He (China) and Hana Simkova (Czech Republic)

09:00-09:30
PLENARY – YIELD GAPS IN WHEAT: PATH TO ENHANCING PRODUCTIVITY

Salon ABCD
J. Hatfield (USA)

Chairs: Brian Beres (Canada) and Bettina Berger (Australia)

**Concurrent Session 6A: Wheat Structural and
Functional Genomics**
Salon ABCD

Chairs: Zhonghu He (China) and Hana Simkova
(Czech Republic)

**Concurrent Session 6B: Wheat Production
Systems: Physiology, Environment and
Management Yield Agronomy**
Centennial Hall A/B

Chairs: Brian Beres (Canada) and Bettina Berger
(Australia)

09:30-09:50
**PAN-TRANSCRIPTOME ANALYSIS OF ELITE
DURUM WHEAT VARIETIES**

Salon ABCD
M. Bruschi (Italy) (S)

09:30-09:50
**MATCHING GENOTYPE AND SOWING TIME TO
OPTIMISE WHEAT FLOWERING TIME AND
YIELD**

Centennial Hall A/B
F. Harris (Australia)



09:50-10:10

**IMPROVED REFERENCE GENOME ASSEMBLY
OF CHINESE SPRING REVEALS STRUCTURAL
CHANGES OF WHEAT A, B AND D
SUBGENOMES COMPARED TO PROGENITOR
GENOMES**
Salon ABCD
M. Luo (USA)

09:50-10:10

**EXPLORING LONG-TERM VARIETY
PERFORMANCE TRIALS TO IMPROVE G × E ×
M RECOMMENDATIONS: A CASE STUDY FOR
WINTER WHEAT**
Centennial Hall A/B
LB. Munaro (Brazil) (S)

10:10-10:30

**A CONSOLIDATED GENE ANNOTATION FOR
THE 10+ WHEAT GENOME PROJECT**
Salon ABCD
T. Lux (Germany)

10:10-10:30

**SUSTAINABLE INTENSIFICATION OF WHEAT
AGRONOMY WITH G × E × M PRINCIPLES**
Centennial Hall A/B
S. Strydhorst (Canada)

10:30-11:00
COFFEE BREAK

11:00-11:20

**SEQUENCE BASED MAPPING IDENTIFIES A
CANDIDATE TRANSCRIPTION REPRESSOR
UNDERLYING AWN SUPPRESSION AT THE B1
LOCUS IN WHEAT**
Salon ABCD
N. De Witt (USA) (S)

11:00-11:20

**UNDERSTANDING WHEAT SPIKE
DEVELOPMENT TO IMPROVE GRAIN YIELD
POTENTIAL**
Centennial Hall A/B
J. Dubcovsky (USA)

11:20-11:40

**FINE-MAPPING OF THE FUSARIUM HEAD
BLIGHT RESISTANCE QTL QFHS.IFA-5A
IDENTIFIED TWO RESISTANCE QTL
ASSOCIATED WITH ANTER EXTRUSION**
Salon ABCD
M. Buerstmayr (Austria)

11:20-11:40

**POST-ANTHESIS GREEN CANOPY DURATION
CONTRIBUTES TO BREEDING PROGRESS OF
GERMAN WINTER WHEAT**
Centennial Hall A/B
C. Lichthardt (Germany) (S)

11:40-12:00

**THE WHEAT NAC TRANSCRIPTION FACTOR
NAC-3 IS A POSITIVE REGULATOR OF
SENESCENCE**
Salon ABCD
SA. Harrington (UK) (S)

11:40-12:00

**GENETIC AND PHYSIOLOGICAL
DETERMINANTS OF WHEAT NITROGEN
RESPONSE**
Centennial Hall A/B
A. Bentley (UK)

Session 7: Protecting Yield: Resistance to Biotic Stresses

Chairs: Beat Keller (Switzerland) and Silvia German (Uruguay)

12:00-12:30

**PLENARY – A TALE OF THREE WHEAT GENES REVEALS THE ABILITY OF A NECROTROPHIC
PATHOGEN TO BAMBOOZLE DIVERSE HOST TARGETS**
Salon ABCD
JD. Faris (USA)



12:30-12:50

ELUCIDATING THE RELATIONSHIP BETWEEN YR7, YR5 AND YRSP: A BED-TIME STORY

Salon ABCD

C. Marchal (UK) (S)

12:50-13:50

LUNCH

13:50-15:40

POSTER SESSION

(POSTERS WILL BE DISPLAYED ALL WEEK)

Themes presented:

- *Structural and Functional Genomics of Wheat and Wheat Relatives*
- *Wheat Improvement: Breeding, Physiology, and Enabling Technologies*
- *Wheat Production Systems: Environment, Sustainability, and Management*

15:40-16:00

MOLECULAR CHARACTERIZATION OF THE DURABLE LR34 DISEASE RESISTANCE GENE

Salon ABCD

S. Krattinger (Saudi Arabia)

16:00-16:20

ADULT PLANT STEM RUST STEM RUST RESISTANCE GENE SR2 REQUIRES A COMPLEX NETWORK OF GENES ON CHROMOSOME 3B AND 4B FOR RESISTANCE

Salon ABCD

R. Mago (Australia)

16:20-16:40

UNCOVERING THE RELATIONSHIPS BETWEEN YR15, YRH52, AND YRG303 – THREE STRIPE RUST RESISTANCE GENES ORIGINATED FROM WILD EMMER WHEAT

Salon ABCD

V. Klymiuk (Israel) (S)

16:40-17:00

WHEAT GENOME ASSEMBLIES PROVIDE NEW INSIGHTS INTO THE MAJOR STEM-SOLIDNESS LOCUS SST1

Salon ABCD

K. Nilsen (Canada)

17:00-17:20

BREEDING WEED COMPETITIVE WHEATS

Salon ABCD

CH. Ingvordsen (Australia)

17:20-18:00

BUSINESS MEETING

Chairs: Curtis Pozniak (Canada, Chair LOC) and Hermann Buerstmayr (Austria, Chair IOC)



▲ **FRIDAY JULY 26 ()**

Session 8: Bridging the Yield Gap
Salon ABCD

Chairs: Hans Braun (Mexico) and Jacques Le Gouis (France)

09:10-09:40

**PLENARY – THE INTERNATIONAL WHEAT YIELD PARTNERSHIP (IWYP) – AN EFFECTIVE
MODEL FOR INTEGRATING WHEAT SCIENCE TO INCREASE YIELD POTENTIAL**

Salon ABCD

J. Gwyn (USA)

09:40-10:00

**WARM NIGHTS DURING DIFFERENT PERIODS OF CROP CYCLE REDUCE YIELD AND ITS
NUMERICAL AND PHYSIOLOGICAL COMPONENTS IN WHEAT AND BARLEY: FROM FIELD
STUDIES TO MODELING**

Salon ABCD

DJ. Miralles (Argentina)

10:00-10:20

**DYNAMICS OF SPRING WHEAT YIELDS IN NORTH AMERICA AND EURASIA IN 1981-2015:
EFFECT OF ENVIRONMENTS, CLIMATE CHANGE AND GERMPLASM ADAPTATION**

Salon ABCD

A. Morgounov (Turkey)

10:20-10:40

GLOBAL NETWORK OF PRECISION FIELD-BASED WHEAT PHENOTYPING PLATFORMS

Salon ABCD

C. Saint Pierre (Mexico)

10:40-11:10

COFFEE BREAK

11:10-11:30

**COMBINING ECO-PHYSIOLOGY, GENETICS AND CROP MODELING TO ENHANCE WHEAT
YIELDS UNDER VARIABLE WATER AVAILABILITY REGIMES**

Salon ABCD

W. Sadok (USA)

11:30-11:50

**SUSTAINABLE INTENSIFICATION OF WHEAT SYSTEMS IN WESTERN INDO-GANGETIC PLAINS
OF SOUTH ASIA FOR IMPROVING PRODUCTIVITY AND FARM PROFITABILITY**

Salon ABCD

PC. Sharma (India)

11:50-12:10

SUCCESSSES AND FAILURES IN INTERNATIONAL WHEAT ROYALTY COLLECTION

Salon ABCD

R. Gray (Canada)

12:10-13:10

LUNCH

13:10-13:30

**TOWARDS SELF-SUFFICIENCY OF WHEAT PRODUCTION IN UGANDA: TRENDS AND
OPPORTUNITIES**

Salon ABCD

B. Bua (Uganda)

13:30-13:50

**SUSTAINABLE WHEAT PRODUCTION IN MEDITERRANEAN AREAS: CONSIDERING CROP
DIVERSIFICATION AS NEW STRATEGY**

Salon ABCD

C. Cantero-Martinez (Spain)

13:50-14:20

CONGRESS CLOSING CEREMONY

Salon ABCD





WWC

1ST INTERNATIONAL
WHEAT CONGRESS

July 21-26, 2019

Saskatoon, Saskatchewan, Canada

DIVERSIFICATION of DURUM WHEAT INDUSTRIAL END-USES through the GENETIC MODIFICATION of its GLUTENIN COMPOSITION & GRAIN TEXTURE

Karim Ammar, Susanne Dreisigacker, Jose Crossa, Roberto Javier Peña, Carlos Guzman – CIMMYT Mexico

Craig F. Morris – USDA-ARS, Pullman WA

Jorge Dubcovsky – UC Davis, CA

Adam Lukaszewski – UC Riverside, CA

Claudia Carter, Teng Vang – CWC, Woodland, CA

DIVERSIFICATION of DURUM WHEAT INDUSTRIAL END-USES through the GENETIC MODIFICATION of its GLUTENIN COMPOSITION & GRAIN TEXTURE

Use in Industrial Bread-making

- **Modification of Glutenin Composition**
 - Introgression of non-endogenous subunits
 - In-depth evaluation of developed germplasm
 - **Can durum wheat make bread industrially?**



Allow Industrial Milling in any Wheat Mill

- **Modification of Grain Texture: Soft Durums**
 - Introgression into Svevo, then into CIMMYT elite lines
 - In-depth evaluation of developed germplasm for bread, pasta, cookies making quality
 - **Can soft durum still make good pasta and what other product can it be use for?**



Boehm et al., 2017



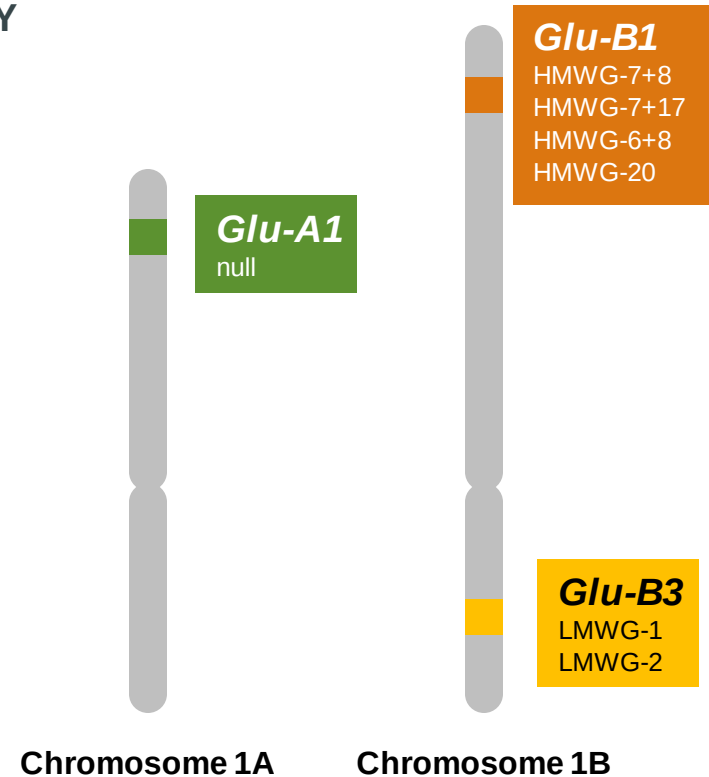
Durum Wheat for Industrial Bread-Making

Need for widening variability for gluten characteristics

► Need to increase strength but mostly EXTENSIBILITY

► Limited variability in glutenin subunits in modern durum germplasm:

- **Glu-A1**: Almost all durum have null allele
- **Glu-B3**: Presence of “strong pattern” LMWG-2 not enough for adequate bread-making
- **Glu-B1**: Some combinations better than other for strength/extensibility, but none enough for adequate bread-making
- **Glu-D1**: Most influential locus in bread wheat, absent in durum

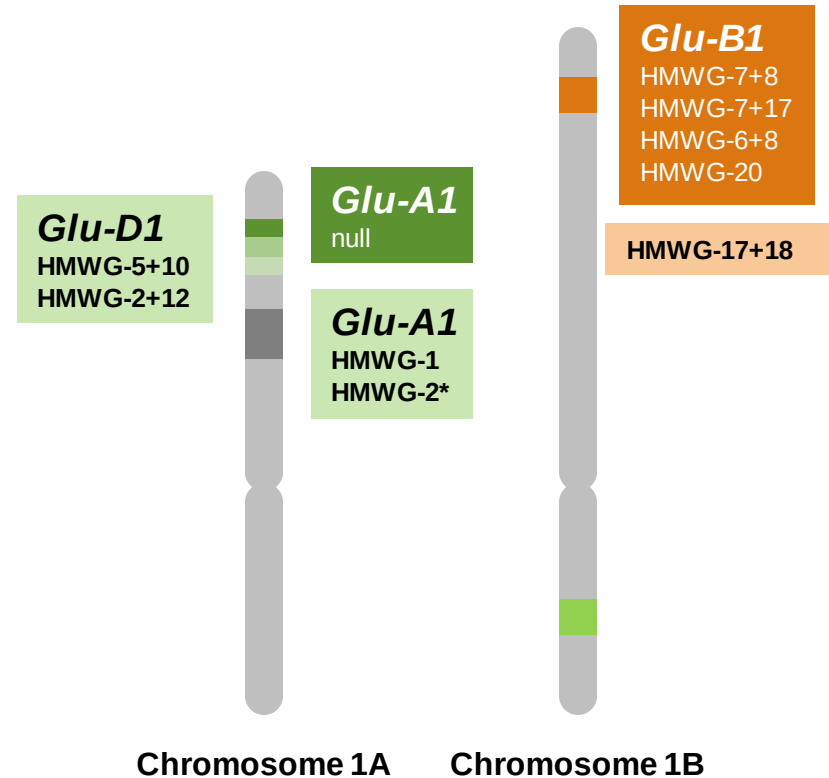


Durum Wheat for Industrial Bread-Making

Improvement via introgression of non-endogenous HMWG glutenin sub-units

► Increase variability in glutenin subunits:

- ***Glu-A1***: Alleles HMWG-1 or 2*
- ***Glu-A1***: Alleles HMWG-5+10 or 2+12 from stocks carrying the ***Glu-D1*** locus translocated onto chromosome 1AL
- ***Glu-B1***: Allele HMWG-17+18



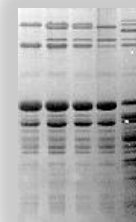
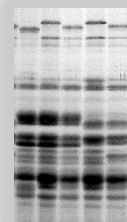
Durum Wheat for Industrial Bread-Making

Development of HMWG-diversified durum germplasm

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

Donor HMWG-17+18, 1, 2*: F₂ plant from cross between PAVON translocation line (A.Lukasevski, UC Riverside) and OPATA, top-crossed to the donor of HMWG-5+10

- ▶ **“Non-endogenous” glutenin combinations into 5 CIMMYT elite lines**
 - All LR/YR resistant, good yield potential & variable quality characteristics
 - Designated as **RP** or **Recurrent Parent**
- ▶ **Selection during backcrossing to RP**
 - SSR marker for HMWG-5+10
 - SDS-PAGE profile on bulk seed from BCF₂ plants
 - Stopped at **BC₅**
- ▶ **Self BC₅ progenies and selection (pedigree)**
 - SNP/STS markers for *Glu-A1*, *Glu-B1* and *Glu-D1* alleles
 - Confirmation by SDS-PAGE on ½ kernels
 - Some selection for agronomic type
 - Stopped at **BC₅F₉**



Evaluation of HMWG-Diversified Durum Germplasm

Germplasm tested in yield trial

Allele at Glu-A1	Allele at Glu-B1	CIMMYT					UC Davis		Individuals per Combination
		RP 1 null / 7+8	RP 2 null / 7+8	RP 3 null / 7+17	RP 4 null / 7+17	RP 5 null / 7+8	RP 6 null / 6+8	RP 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 RP		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 NILs:

- 62 BC₅F₁₂ lines with variable HMWG combinations
- In 5 elite backgrounds (RP)

► UC Davis NILs

- 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

Experimental setup

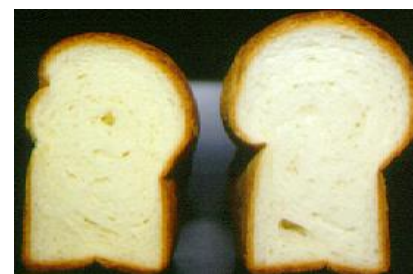
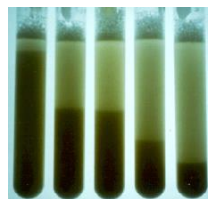
► Field Trial in CENEB-Obregon 2017 & 2018

- 75 genotypes in 2-reps RCBD
- Full irrigation, optimal management, fungicide protection



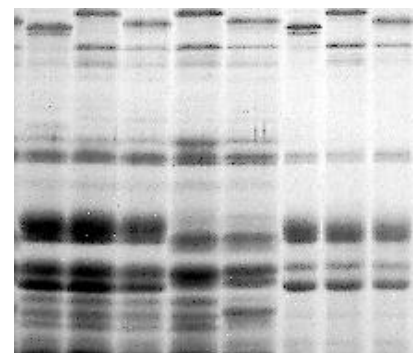
► Agronomic Traits

- Heading & maturity
- Plant Height
- Grain yield



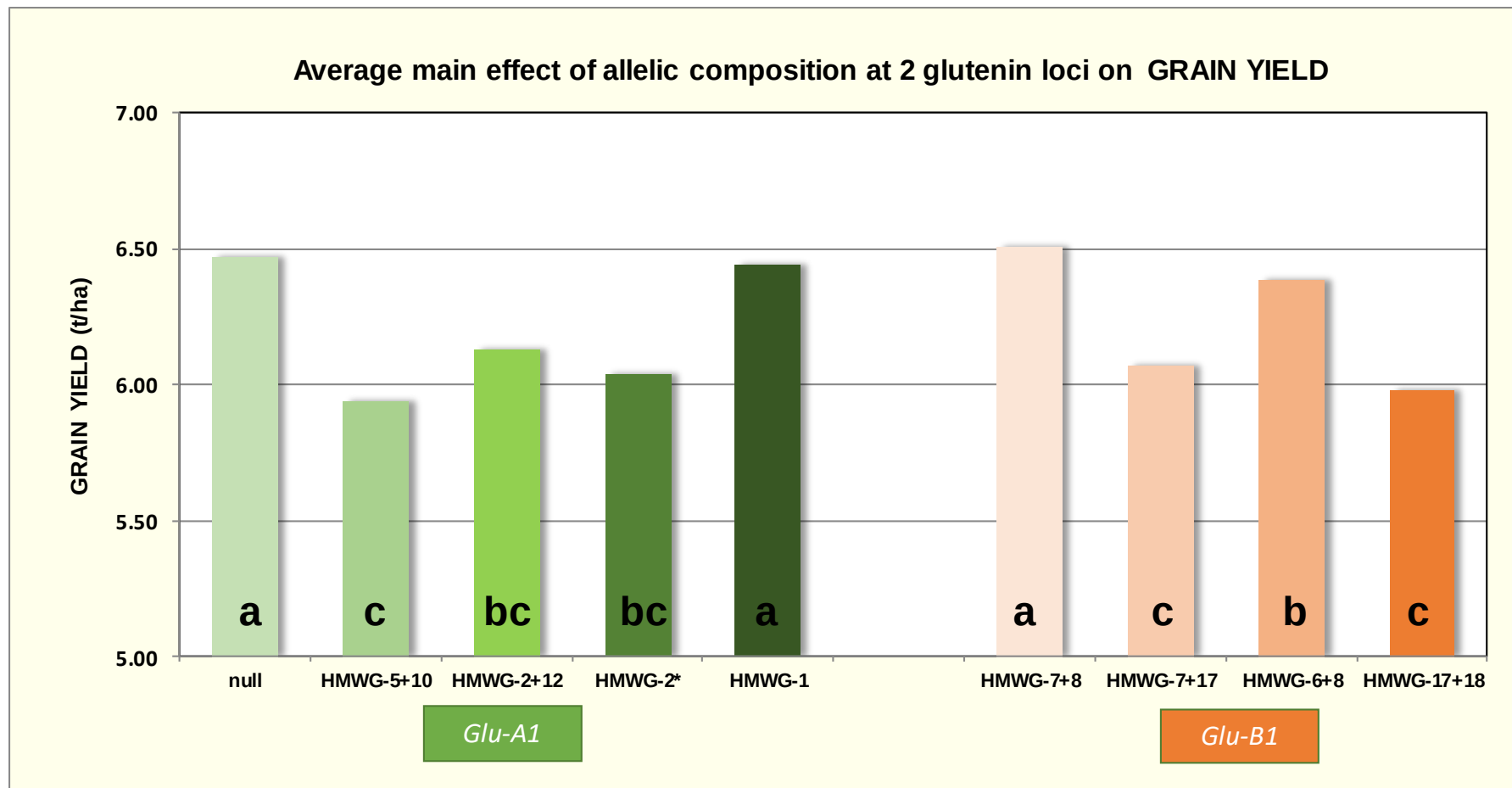
► Quality Traits

- 1000 Kernel Weight, Test weight
- Kernel Characteristics (image analysis, SKCS)
- Grain/Flour Protein Content (NIR, 12.5%/14% mb)
- SDS-Sedimentation Volume (1 gr. ground wheat + flour)
- 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 MW Glutenin Sub-Units)



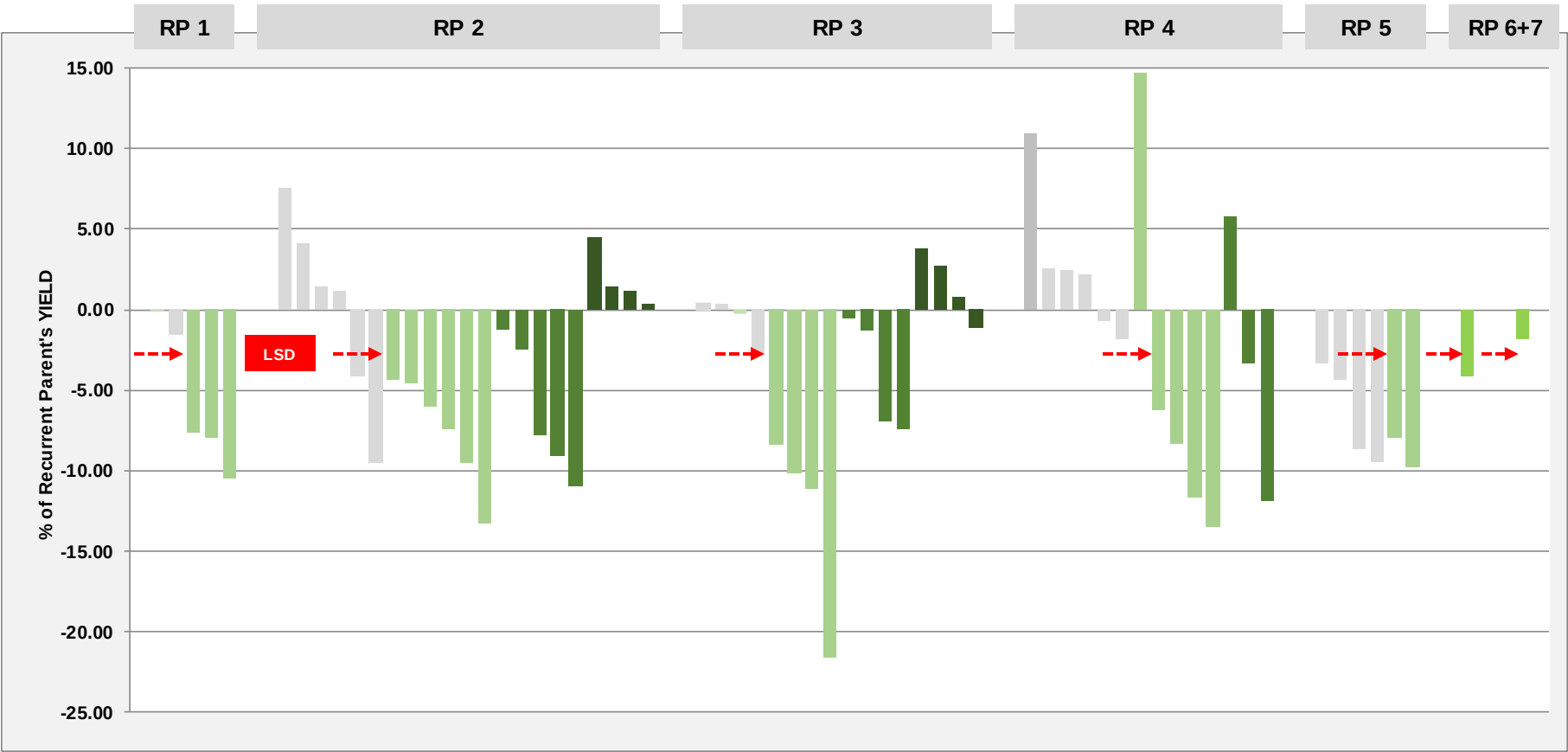
Durum Wheat for Industrial Bread-Making

*Non-endogenous HMWG glutenin subunits: effect on **Grain Yield***



Durum Wheat for Industrial Bread-Making

Non-endogenous HMWG glutenin sub-units: effect on Grain Yield

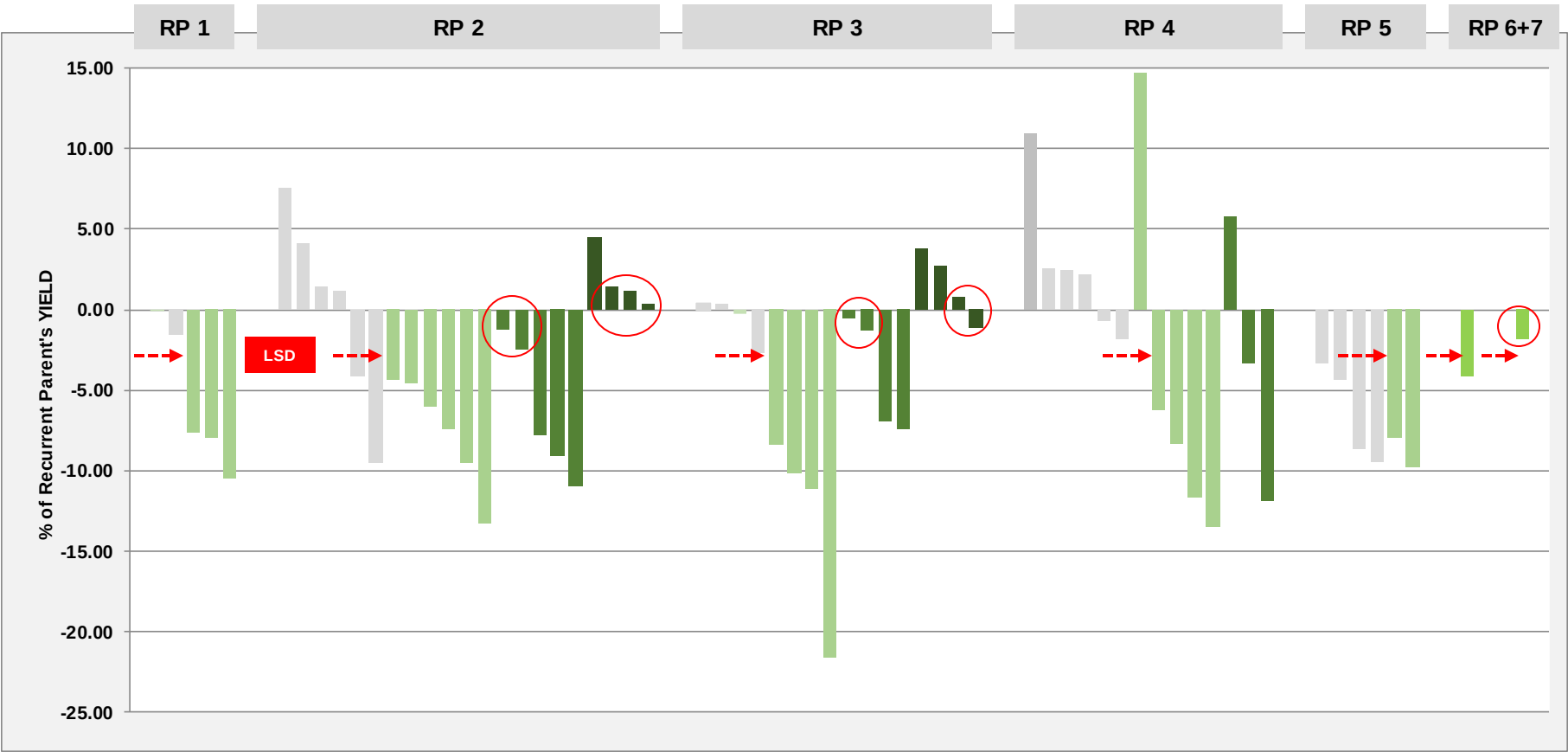


HMWG Allele at *Glu-A1*: Null 5+10 2+12 2* 1



Durum Wheat for Industrial Bread-Making

Non-endogenous HMWG glutenin sub-units: effect on Grain Yield

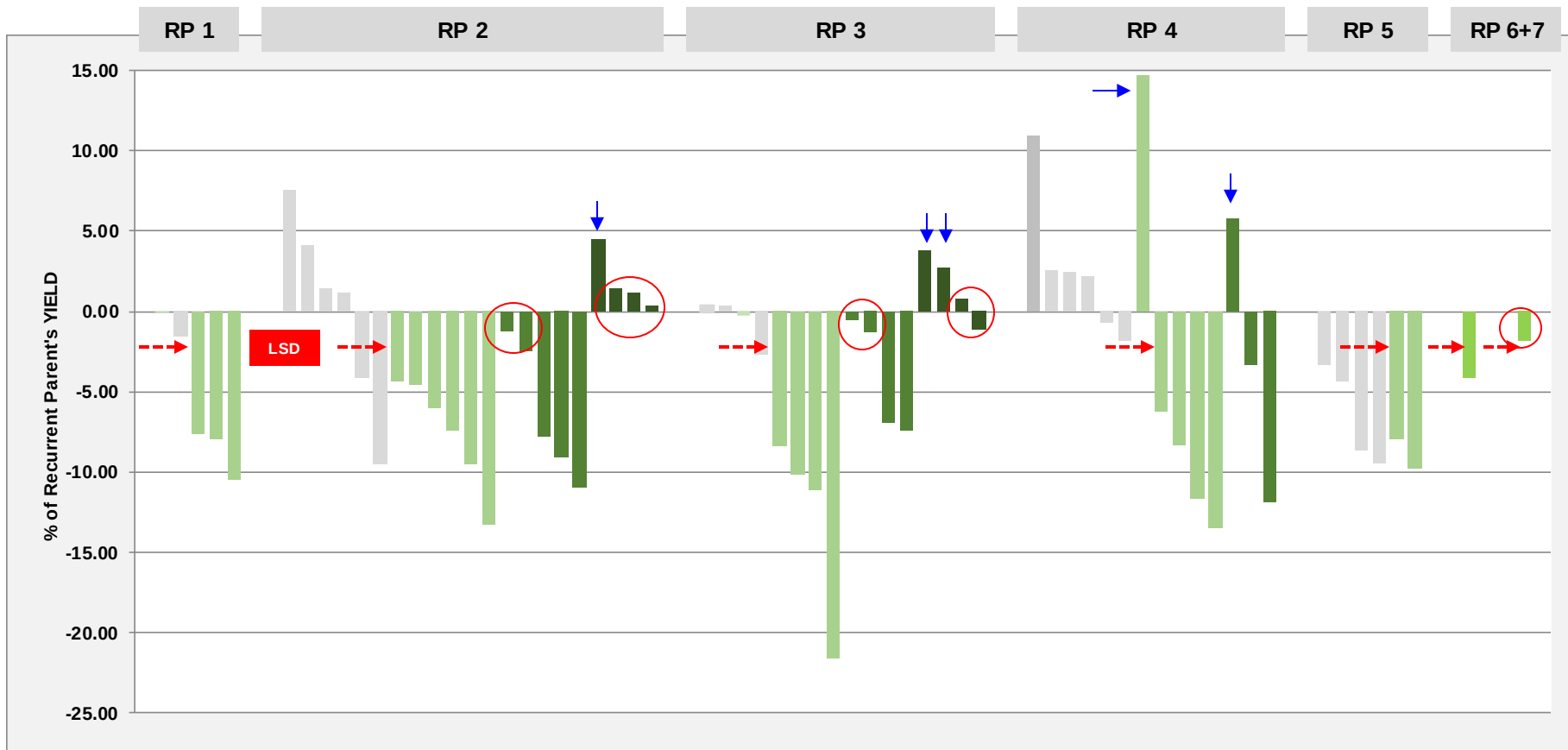


HMWG Allele at *Glu-A1*: Null 5+10 2+12 2* 1



Durum Wheat for Industrial Bread-Making

Non-endogenous HMWG glutenin sub-units: effect on Grain Yield



HMWG Allele at **Glu-A1**:

Null

5+10

2+12

2*

1

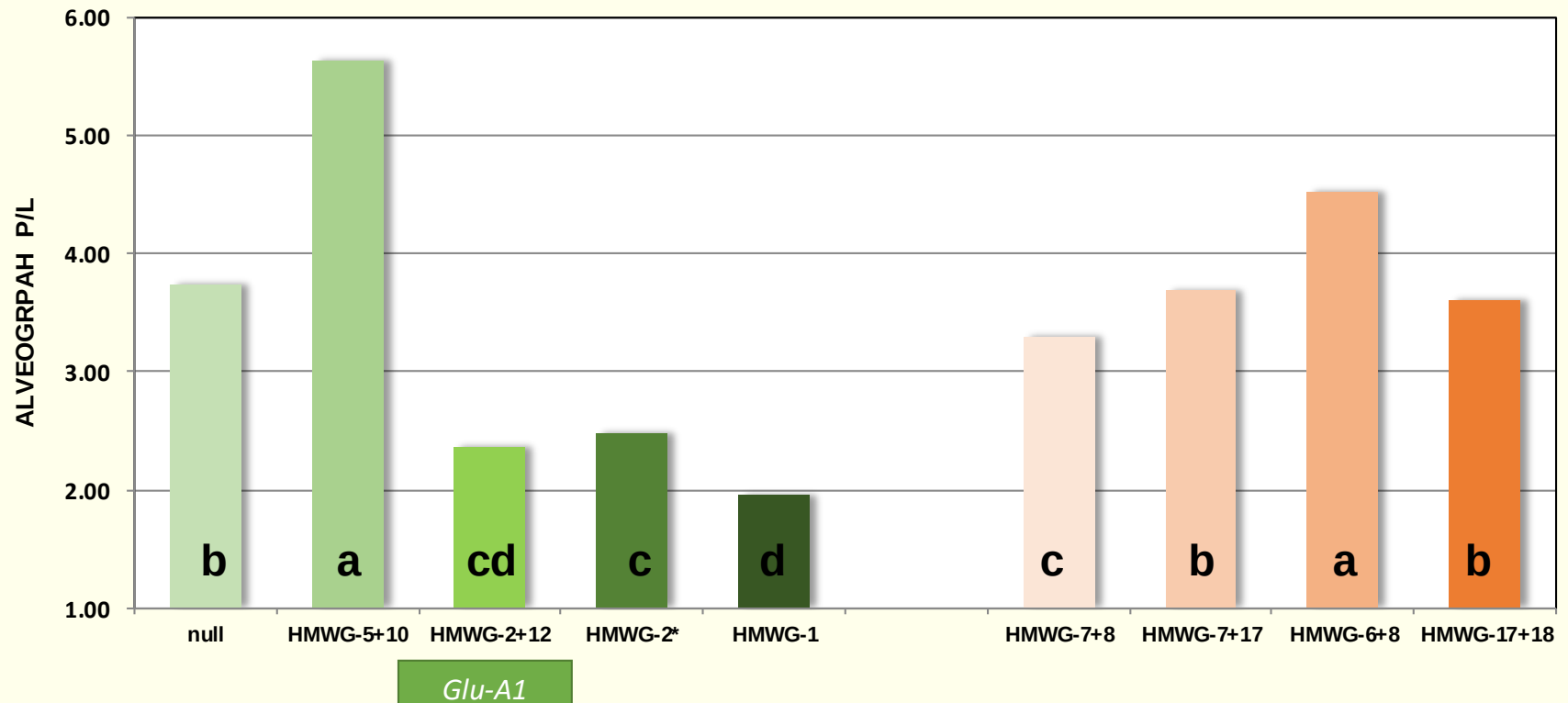
HMWG Allele 17+18 at **Glu-B1**: Some lines not significantly different from RP in backgrounds 3 & 4



Durum Wheat for Industrial Bread-Making

*Non-endogenous HMWG glutenin sub-units: effect on **Extensibility***

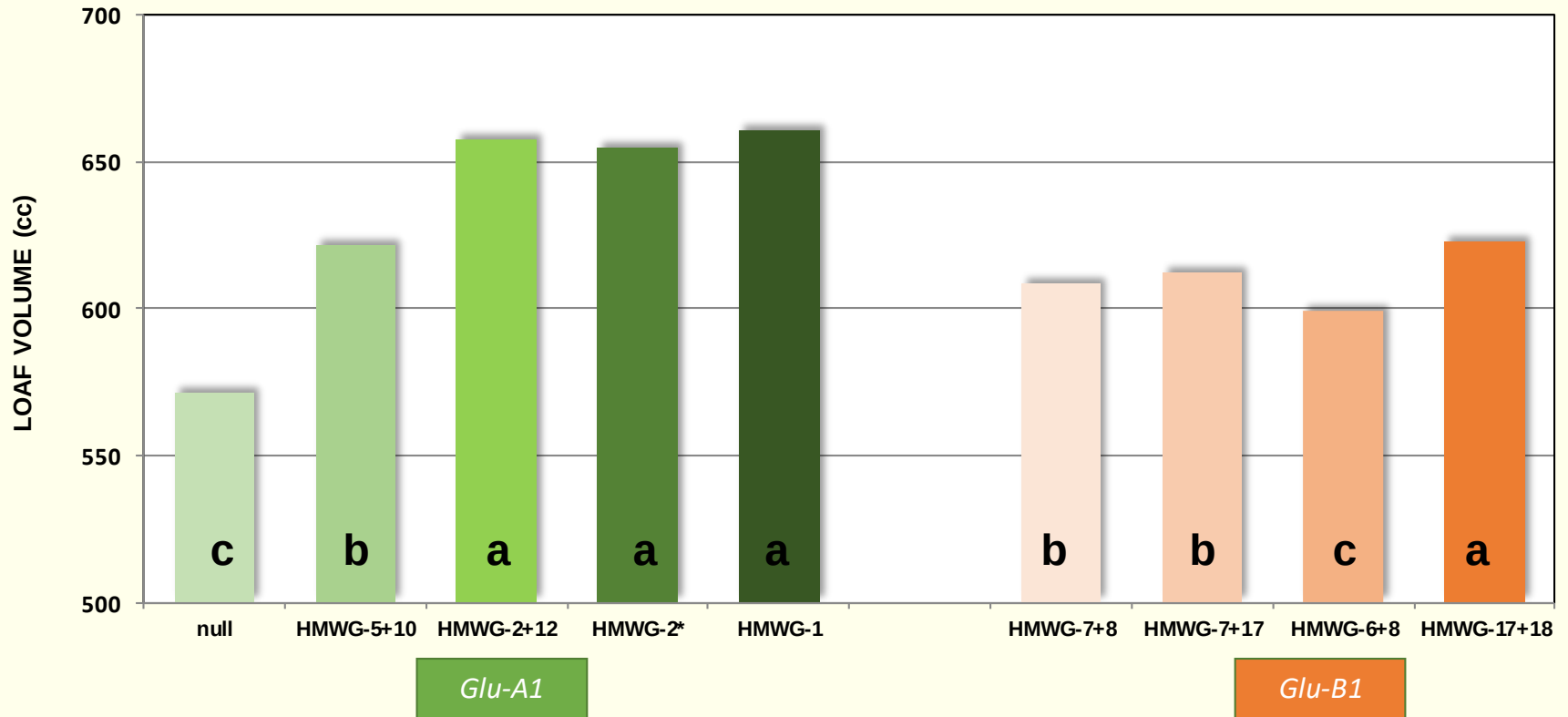
Average main effect of allelic composition at 2 glutenin loci on EXTENSIBILITY



Durum Wheat for Industrial Bread-Making

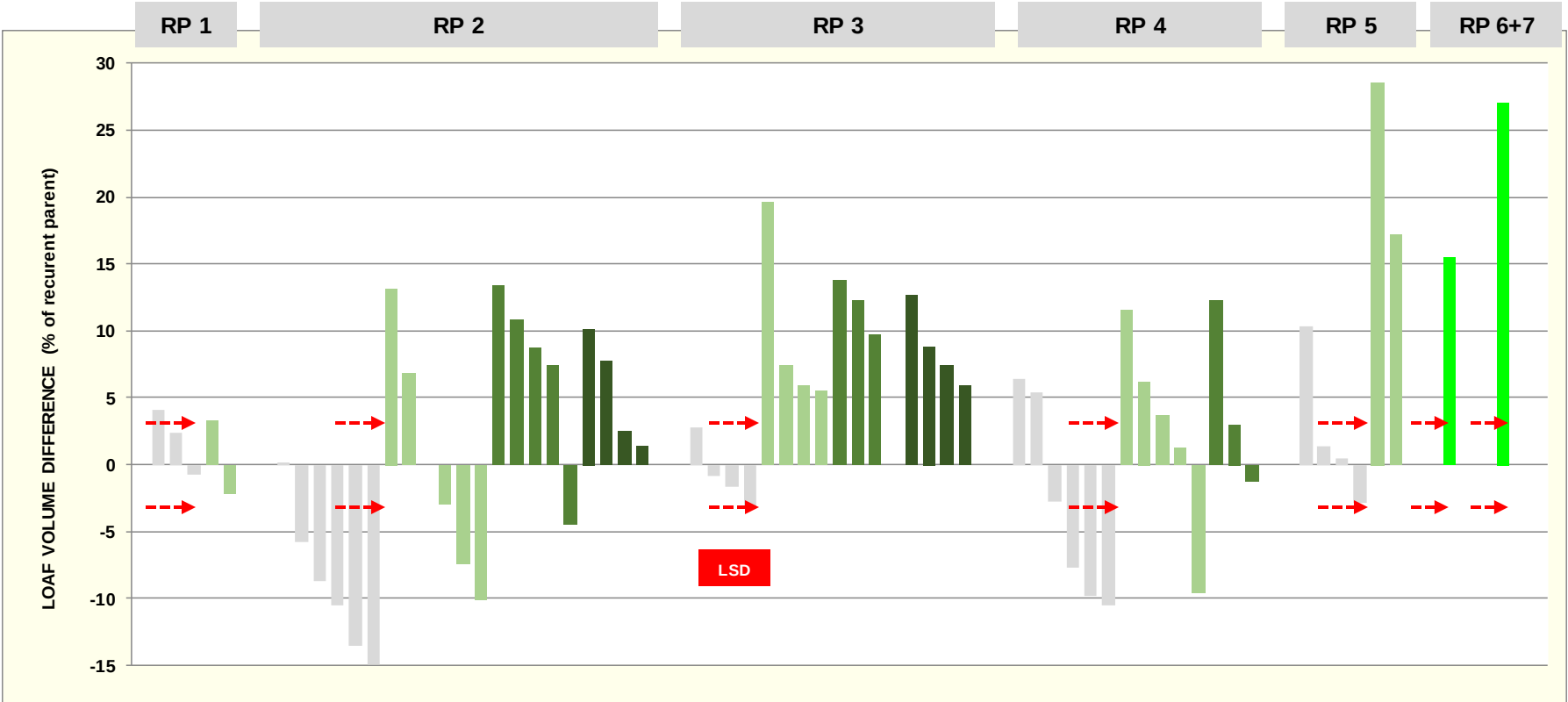
*Non-endogenous HMWG glutenin sub-units: effect on **Loaf Volume***

Average main effect of allelic composition at 2 glutenin loci on LOAF VOLUME



Durum Wheat for Industrial Bread-Making

*Non-endogenous HMWG glutenin sub-units: effect on **Loaf Volume***

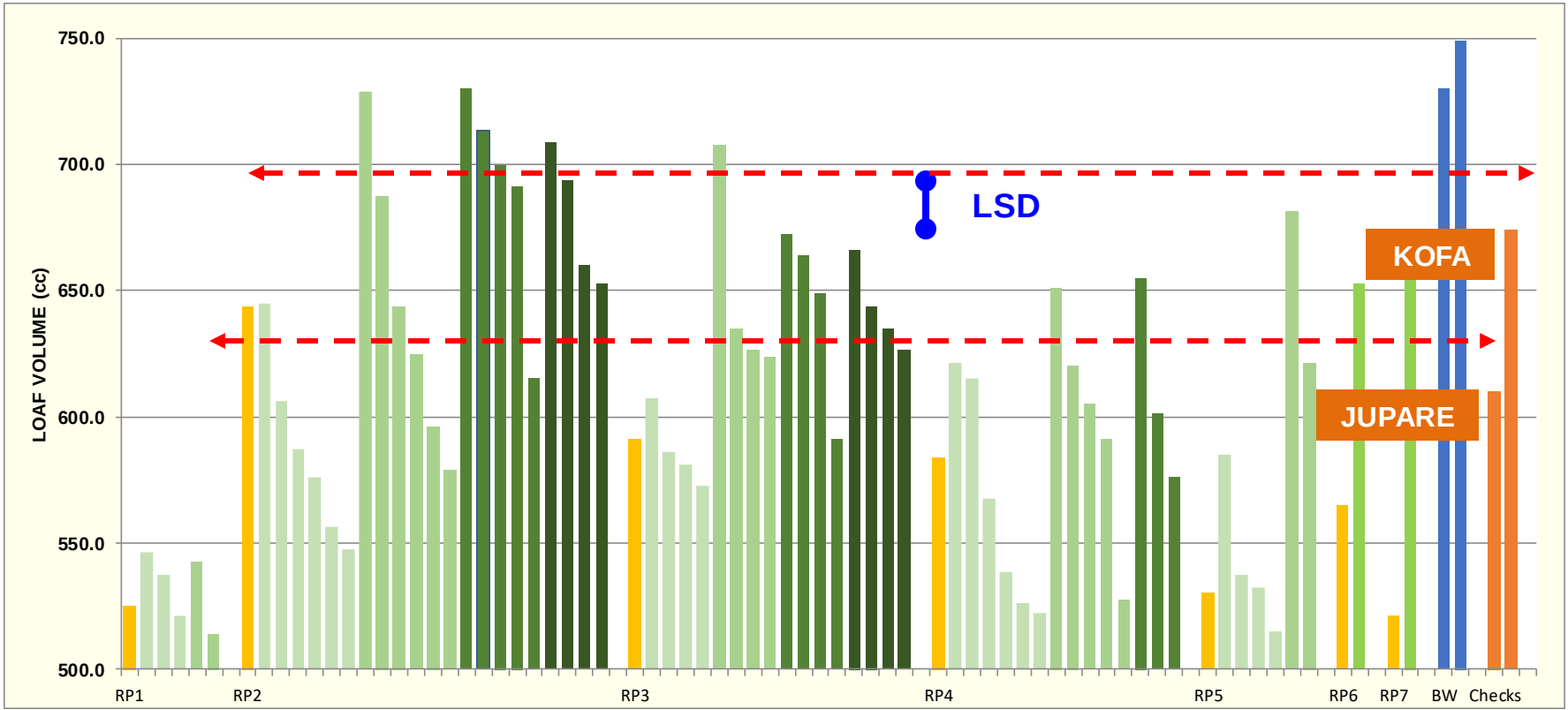


HMWG Allele at *Glu-A1*: Null 5+10 2+12 2* 1



Durum Wheat for Industrial Bread-Making

*Non-endogenous HMWG glutenin sub-units: effect on **Loaf Volume***

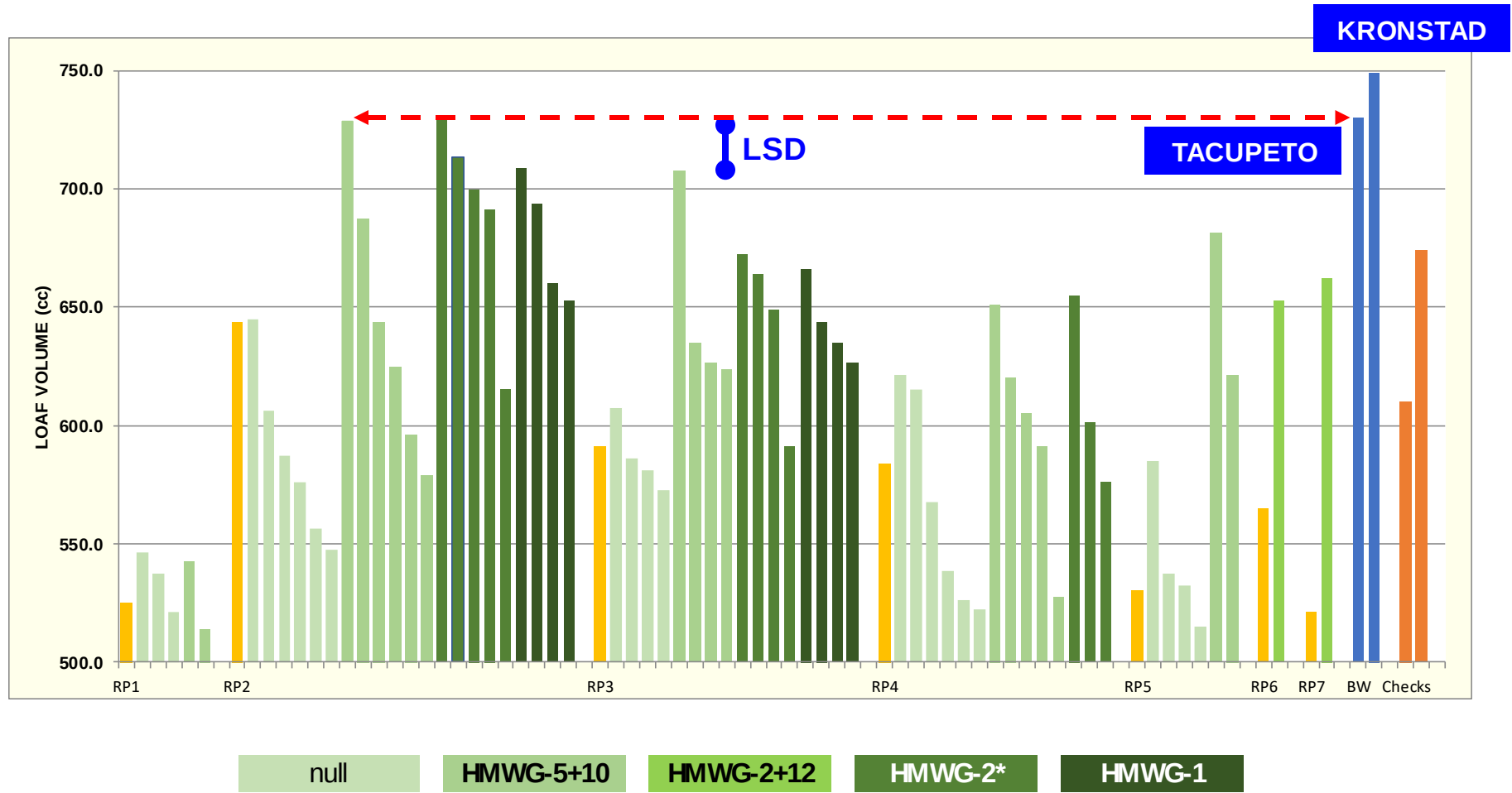


Legend: null (light green), HMWG-5+10 (medium green), HMWG-2+12 (dark green), HMWG-2* (very dark green), HMWG-1 (black)



Durum Wheat for Industrial Bread-Making

*Non-endogenous HMWG glutenin sub-units: effect on **Loaf Volume***



Conclusions I

Diversification of durum's HMWG profiles can be achieved without loss in yield

- ▶ **Yield depreciation in stocks carrying non-endogenous HMWG subunits can be overcome through selection**
 - Non-endogenous subunits generally associated with lower yields, except for HMWG-1
 - Lines carrying non-endogenous subunits but no-significant yield depreciation compared to RP were identified
 - Lines carrying HMWG-5+10/2*/1 with a significant yield advantage over RP were identified in **rare** cases



Conclusions I

Diversification of HMWG profiles can improve bread-making quality of Durum Wheat

► Variable effect of non-endogenous HMWG subunit on gluten extensibility

- HMWG-2+12/2*/1 substantially decrease alveograph P/L
- HMWG-5+10 substantially increases tenacity (larger P/L)
- HMWG-17+18 does not provide significant advantage over endogenous Glu-B1 subunits

► Loaf Volume can be substantially increased by any of the non-endogenous HMWG subunits

- HMWG-2+12/2*/1 were associated with the largest average improvement of baking quality, also associated with increased extensibility
- In spite of being associated with high tenacity, HMWG-5+10 was also associated with a substantial average increase in loaf volume
- On average, HMWG-17+18 modestly increased loaf volume



Conclusions I

Diversification of HMWG profiles can improve bread-making quality of Durum Wheat

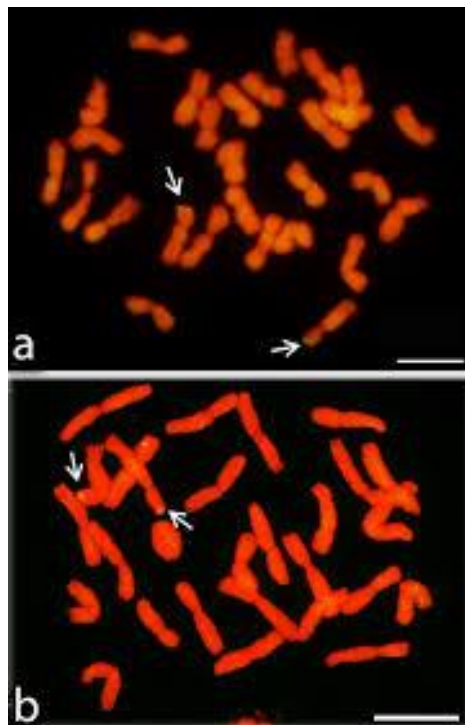
- ▶ **Industrial bread production using durum wheat flour is now possible thanks to the diversification of HMWG profiles**
 - Two lines with loaf volumes equal to that of TACUPETO, one not significantly inferior to that of the high quality check KRONSTAD were identified
 - Both carried non-null allele at *Glu-A1*

- ▶ **Breeding for outstanding baking quality cannot rely on selection for a single non-endogenous HMWG subunit. Anyone can be useful depending of how it interacts with the endogenous gluten complex**
 - Of the two best lines, one carried HMWG-5+10/HMWG-6+8 and the other HMWG-2*/HMWG-17+18
 - Other lines with loaf volumes similar to that of TACUPETO carried HMWG-1, the largest increase in loaf volume compared to RP was obtained with HMWG-2+12
 - Inter-subunit interactions effects can be greater than main effects



Soft Durum Wheat – Characteristics & Potential Uses

Germplasm used



Boehm et al., 2017

- ▶ **Crosses SOFT SVEVO x CIMMYT Elite lines (USDA-ARS, Pullman)**
 - SOFT SVEVO carry a 5DS/5AS translocation with the Chinese Spring Softness allele
 - MAS/Visual seed selection F₂-F₆

 - ▶ **F6 seed homozygous for translocation provided to CIMMYT**
 - 2 rounds of selection for leaf rust resistance and agronomic type
 - Confirmation of softness via markers and NIR
- ▶ **8 selected Soft Durum lines (RILs)**
 - ▶ **2 Checks: JUPARE C2001, CIRNO C2008**



Soft Durum Wheat – Characteristics & Potential Uses

Experimental Setup

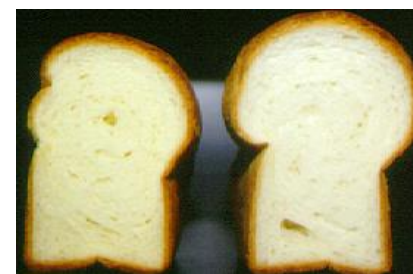
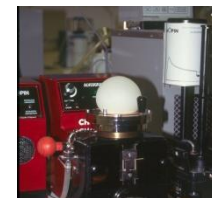
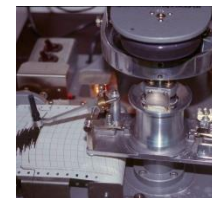
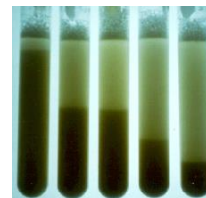
► Field Trial in CENEB-Obregon 2017 & 2018

- 10 genotypes in 3-reps RCBD
- Full irrigation, optimal management, fungicide protection



► Agronomic Traits

- Heading & maturity
- Plant Height
- Grain yield



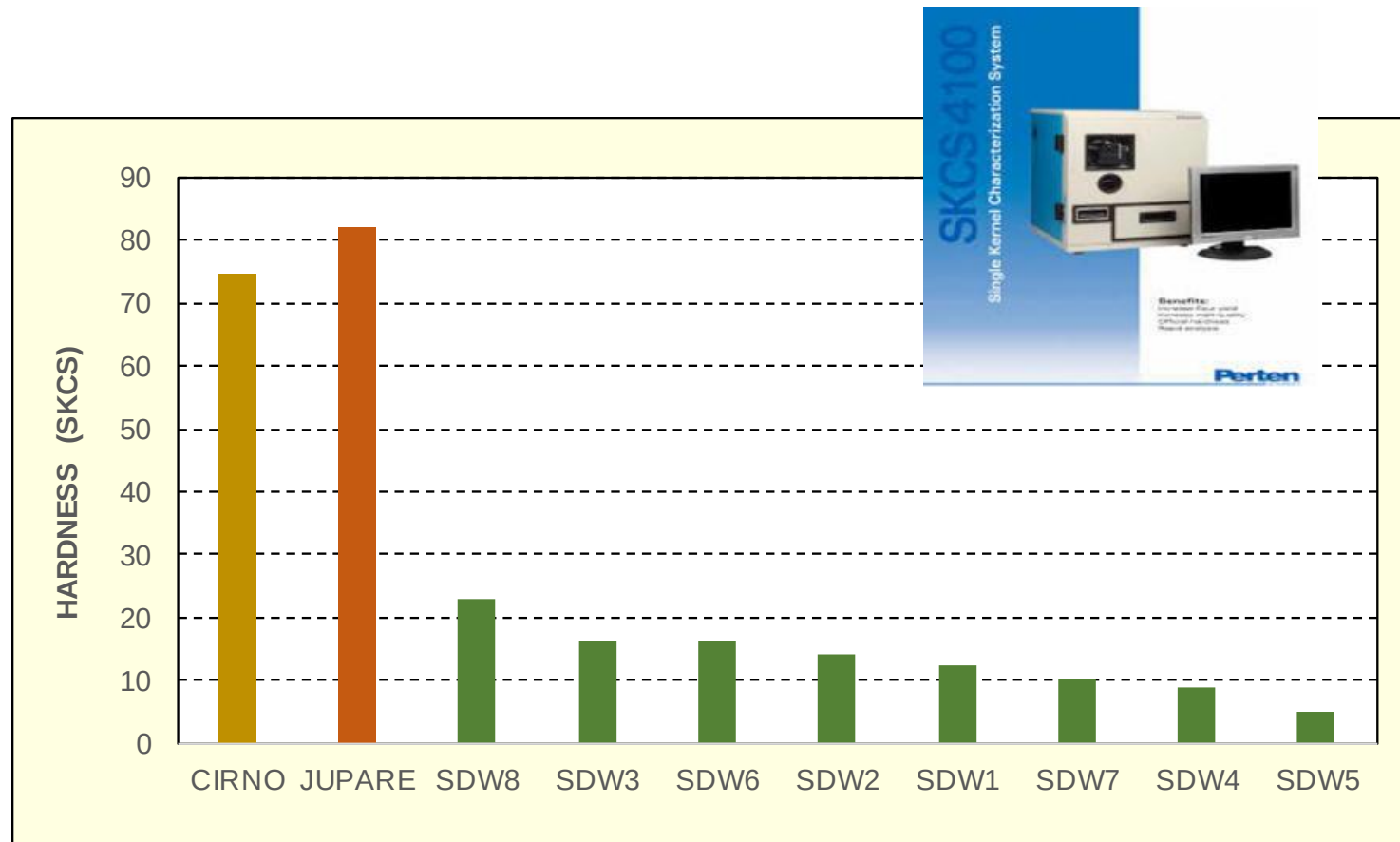
► Quality Traits

- 1000 Kernel Weight, Test weight
- Kernel Characteristics (image analysis, SKCS)
- Grain/Flour Protein Content (NIR, 12.5%/14% mb)
- SDS-Sedimentation Volume (1 gr. ground wheat + flour)
- Yellow color (b-value, colorimeter, ground wheat + flour)
- Milling Yield
- Alveograph on flour (W, P/L) **(CIMMYT+CWC)**
- Mixograph on flour **(CIMMYT+CWC)**
- Bread making properties (Loaf volume + Bread Crumb Appearance)
- Pasta making properties (Cooking Weight, Loss, Firmness) **(CWC)**
- Cookie characteristics **(CIMMYT)**



Soft Durum Wheat – Characteristics & Potential Uses

Results - Hardness



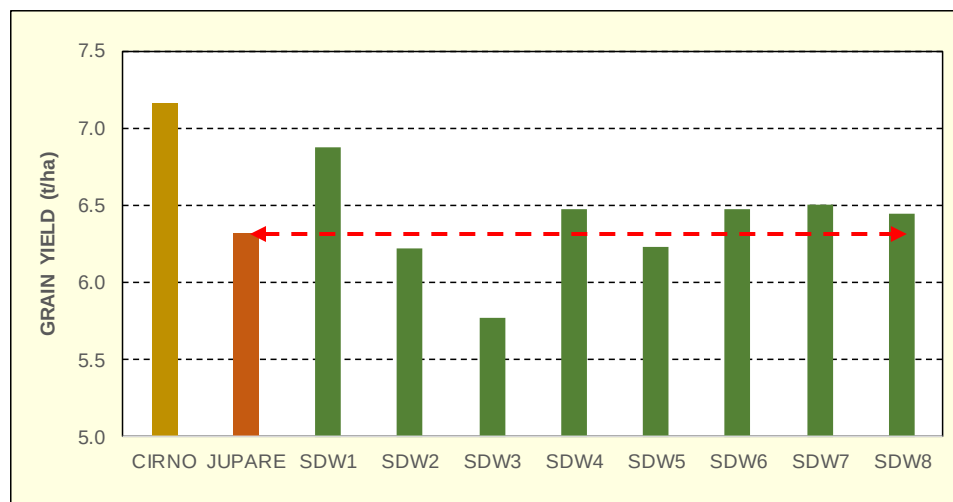
► Extra soft texture

- Softer than bread-making bread wheat
- As soft as a “cookie” wheat



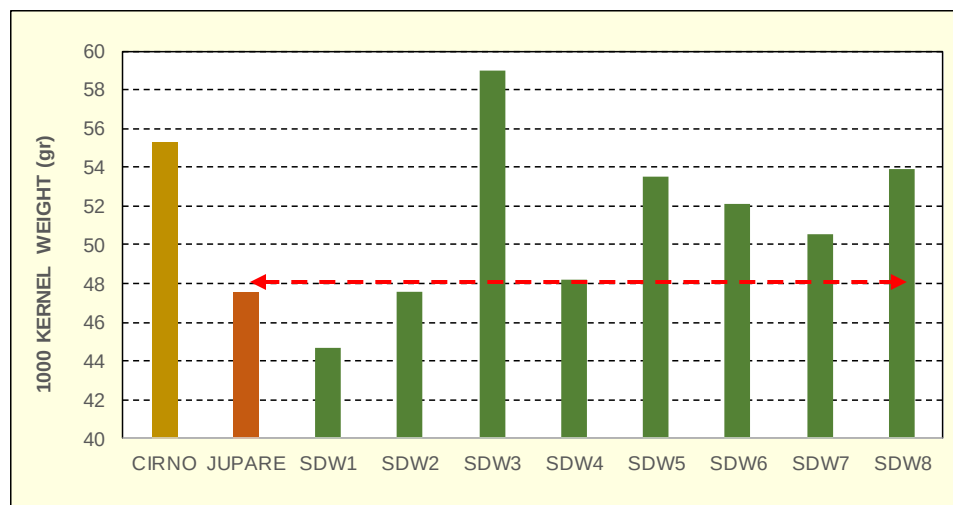
Soft Durum Wheat – Characteristics & Potential Uses

Results – Grain Yield & Size



► No apparent yield penalty

- Most as good or better than JUPARE C2001
- 1 RIL not significantly lower than CIRNO C2008



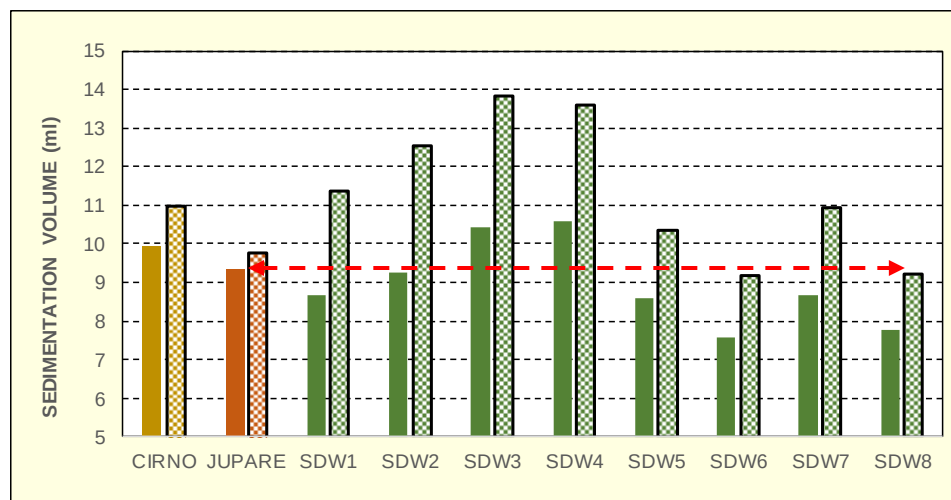
► No penalty in Grain Size

- Most as good or better than JUPARE C2001
- 1 RIL significantly greater than CIRNO C2008



Soft Durum Wheat – Characteristics & Potential Uses

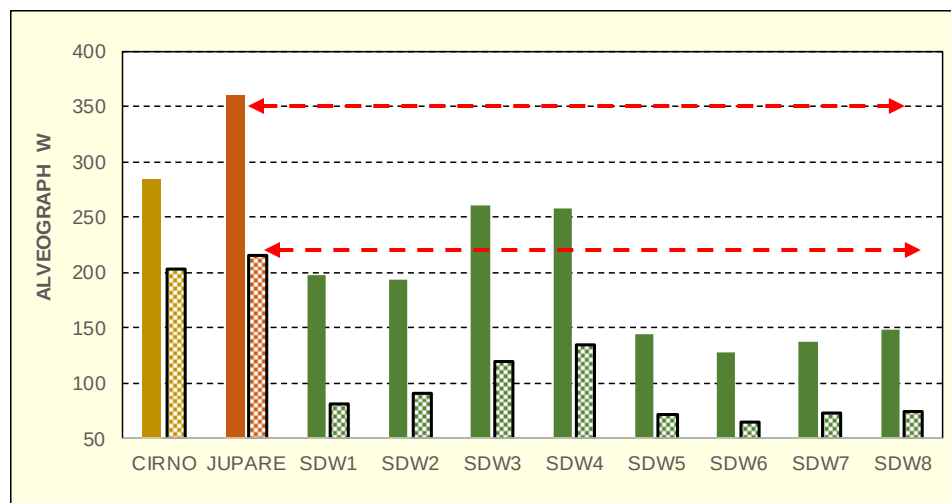
Results – Gluten Strength



Ground Wheat Refined Flour

► No systematic effect on gluten strength as per Sedimentation Volume

- Probably related to different genetic backgrounds independently from softness gene
- Same in refined flour as in ground wheat



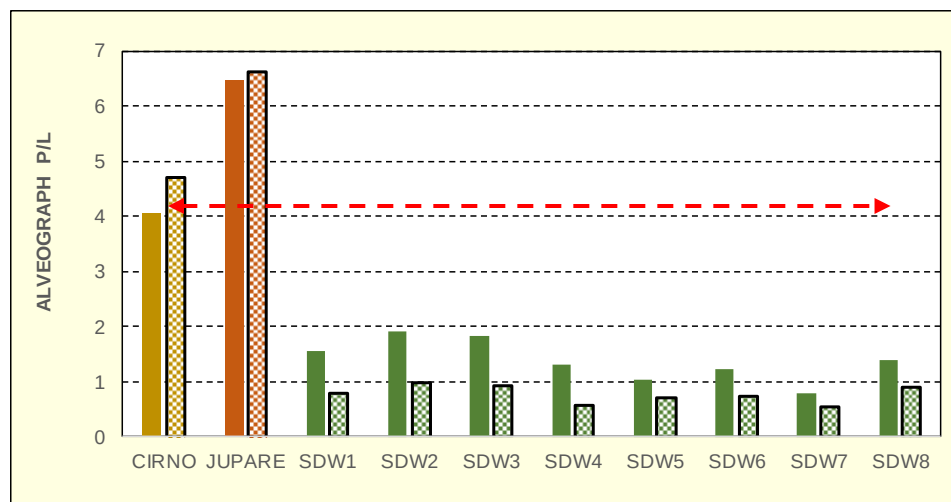
CIMMYT lab CAL. WC lab

► Apparently lower gluten strength based on Alveograph W

- Probably related to over-hydration of soft samples (no starch damage) & “artefact” of the testing protocol

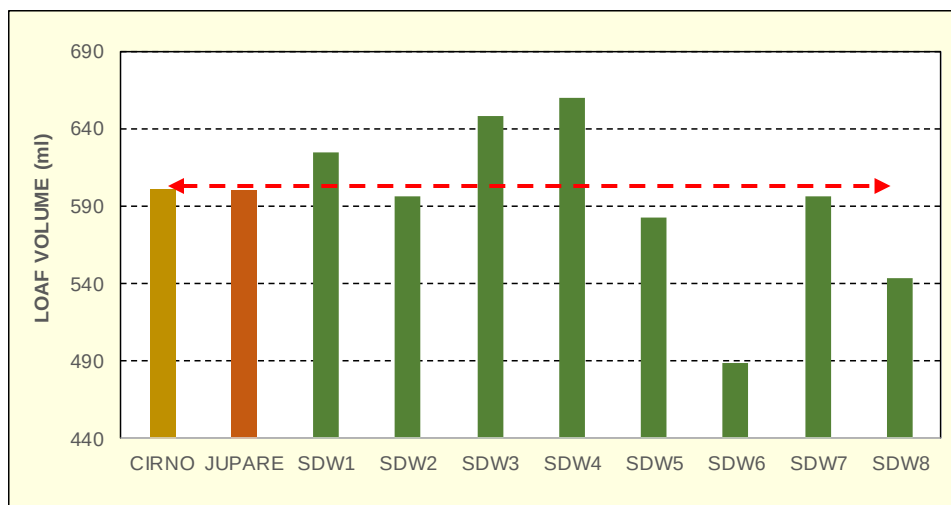
Soft Durum Wheat – Characteristics & Potential Uses

Results – Extensibility & Baking Quality



CIMMYT lab CAL. WC lab

- ▶ **Substantially greater apparent extensibility based on Alveograph P/L, similar values to bread wheat flours**
 - Probably related to over-hydration of soft samples (no starch damage) & “artefact” of the testing protocol

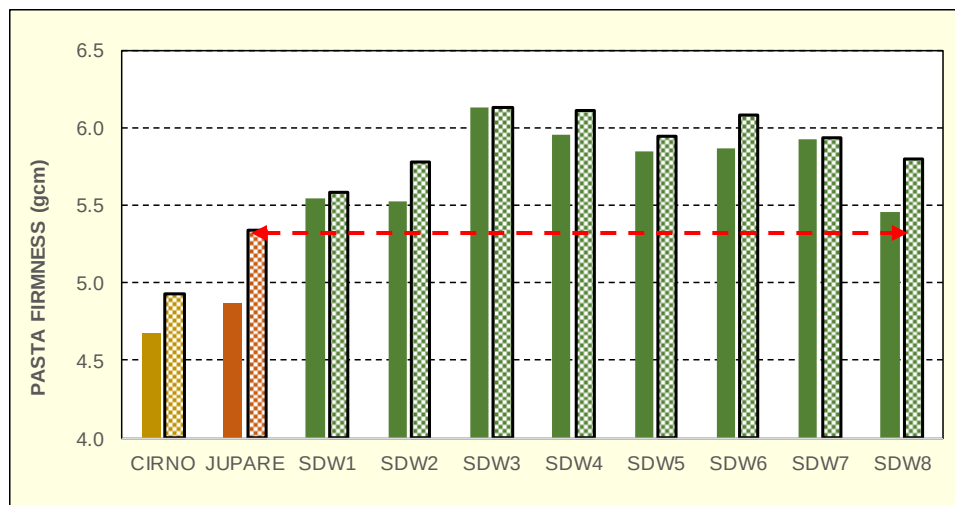


- ▶ **No systematic effect on baking quality based on Loaf Volume**
 - Typical range of values for durum wheat
 - Not consistent with drastic reduction in apparent gluten strength (low W) and increased extensibility (low P/L)



Soft Durum Wheat – Characteristics & Potential Uses

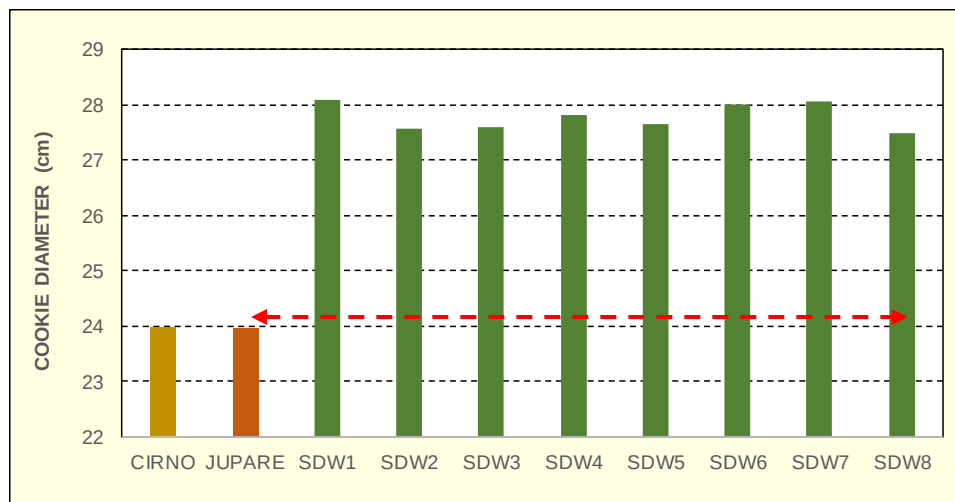
Results – Pasta-making & Cookie-making Quality



■ 12 min. cooking ■ Optimum cooking

► Positive effect on pasta quality associated with soft texture

- Most RILs produce a very firm strand, some substantially more than checks



► Positive effect on Cookie quality associated with soft texture

- All RILs produce a cookie with a substantially larger diameter than the checks



Conclusions II

Characteristics & potential uses of soft-durum wheat

- ▶ **5DS/5BS translocation surprisingly neutral to yield and kernel size**
- ▶ **Soft texture does not negatively affect bread-making characteristics**
 - Values typical of durum wheat, more dependent on background than the presence of 5DS/5BS translocation
 - Any bread-making quality enhancing modification of gluten composition most likely to be expressed
 - **Combination Soft texture/Novel glutenin subunits can enhance possibilities of industrial uses of durum wheat for bread-making**
- ▶ **Soft durum makes as good of a pasta or better than hard durum**
 - Generally firmer pasta with less cooking loss
 - **Key “traditional” quality attribute of durum wheat is not negatively affected by the soft texture**
- ▶ **Soft texture enhances cookie-making quality**
 - Greater cookie diameter and properties
 - **Potentially new end-use for durum**



**BILL &
MELINDA
GATES
foundation**

**“Delivering Genetics
Gains in Wheat”**

DFID Department for
International
Development

Funding & Support for Durum Wheat Breeding at CIMMYT



India

Sonora - Mexico



Spain



Australia



Canada - Saskatchewan



CIMMYT – coordinated initiatives



CRP - WHEAT



Foundations:





iWc

1ST INTERNATIONAL
WHEAT CONGRESS



Durum Wheat Mosaic, Oudhna-Tunisia
Courtesy of M.S. Gharbi - INRAT

Thank You...

