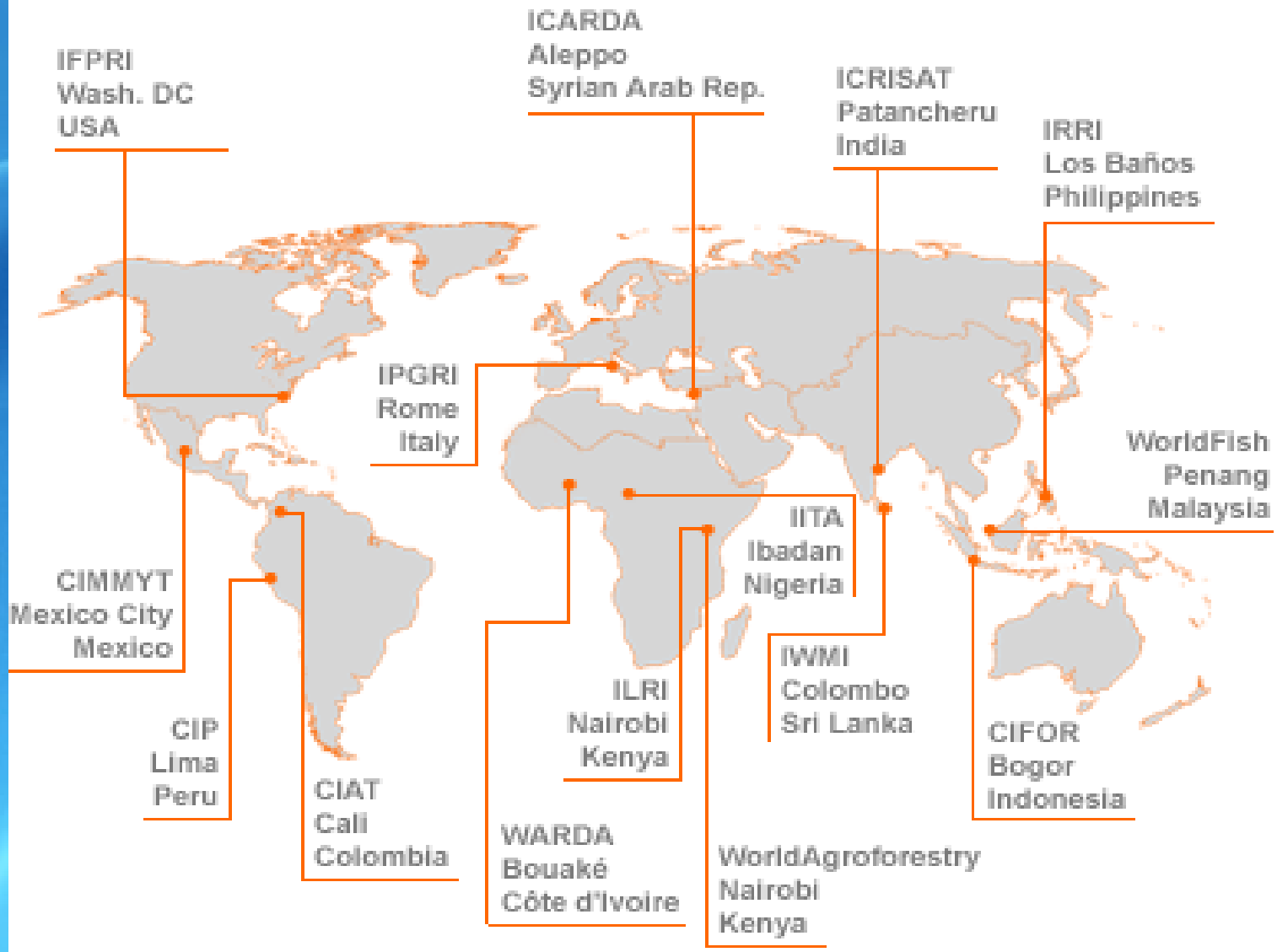
CIMMYT‘s Wheat Breeding

Jiankang Wang



Select the Area of your interest on the map

CIMMYT's headquarter in Mexico

CIMMYT's global mandate


BUENA
SUERTE
JIAN KANG WANG

Structure before 2002

- Wheat Program
- Maize Program
- Economics Program
- Natural Resources Program
- Applied Biotechnology

New CIMMYT 2002-2006

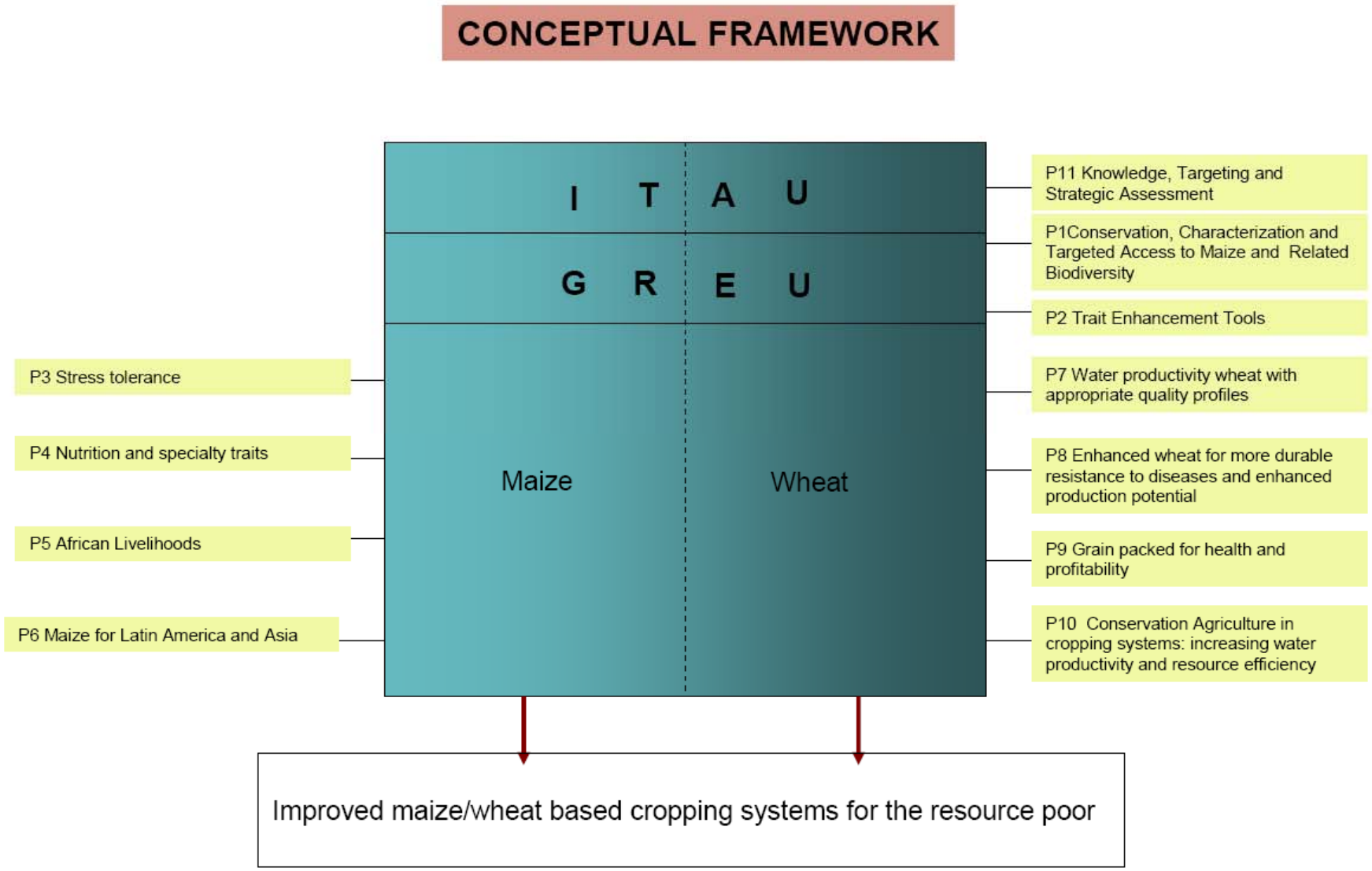
Figure 3.1. CIMMYT's research structure. Six broad, thematic programs, focusing on global and eco-regional issues, will catalyze interdisciplinary research done in collaboration with a range of partners. The programs will interact with groups representing expertise in specific disciplines, whose role is to ensure continuing scientific excellence.

Disciplinary input	Global research program		Eco-regional research program			
	Genetic resources	Global and strategic research	Sustaining African livelihoods	Rainfed systems	Tropical ecosystems	Irrigated, high-potential maize and wheat systems
Maize improvement	60%			40%		
Wheat improvement						
Biotechnology						
Social sciences						
Crops and resource management						

Flagship products in 2006-2010

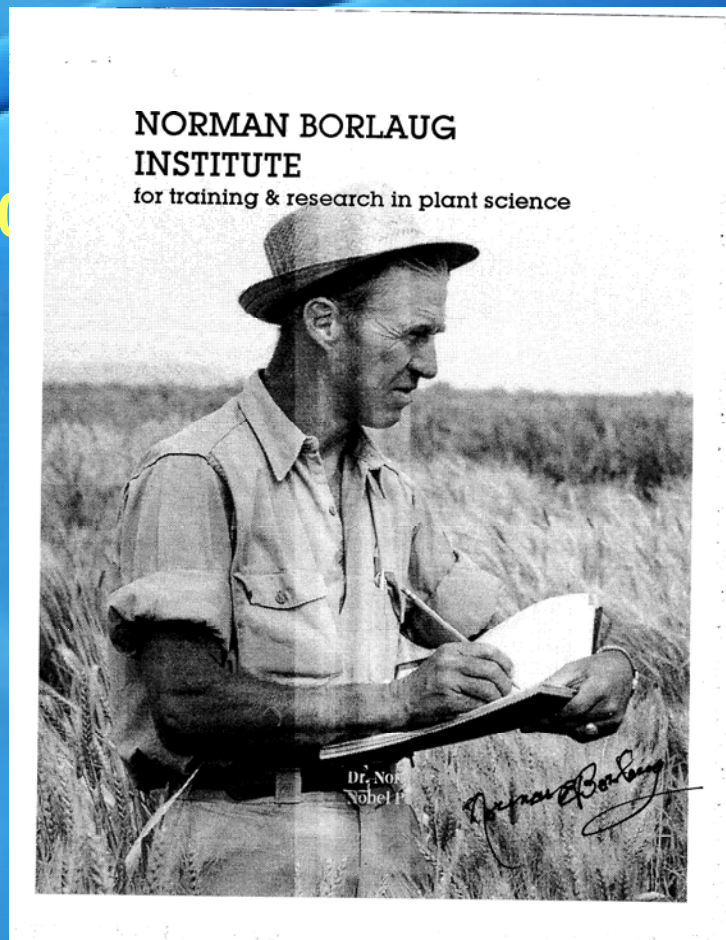
- 1) Stress tolerant maize for enhanced food security and crop diversification
- 2) Wheat with enhanced water productivity and appropriate quality profiles
- 3) Rust resistant wheat
- 4) Biofortified maize for improved nutrition and health
- 5) New traits through allele and gene mining of global crop-related biodiversity
- 6) Improved methodologies and tools for genetic improvement
- 7) Capacity building of NARS and SME breeding programs
- 8) Resource conservation technologies for maize and wheat cropping systems
- 9) Opportunities for income generation from special trait maize

Structure after 2006



Dr. Borlaug and green revolution

- Mexican-Rockefeller Foundation Agricultural Program, 1944
- Mexico became self-sufficient in most food commodities by the late 1950s
- Young scientists were trained in Mexico
- Semidwarf wheats (*Rht1* gene and Norin 1
- 1965-1975, wheat and rice production had increased by 50%
- Awarded Nobel Peace Prize in 1970
- Criticism of the Green Revolution
  - The rich got richer, the poor got poorer
  - Environment damage
  - Loss of biodiversity



CIMMYT's Shuttle breeding

GLOBAL center for wheat global research

Crop Improvement:
- Breeding
- Pathology
- Physiology
- Cereal Chemistry
- Applied Biotechnology

Crop Management:
- Agronomy
- Plant nutrition
- Water management
- Mechanization
- Conservation agriculture

TRAINING & NETWORKING

Genetic Resources:
- Collection
- Conservation
- Documentation
- UTILIZATION
- Pre-breeding

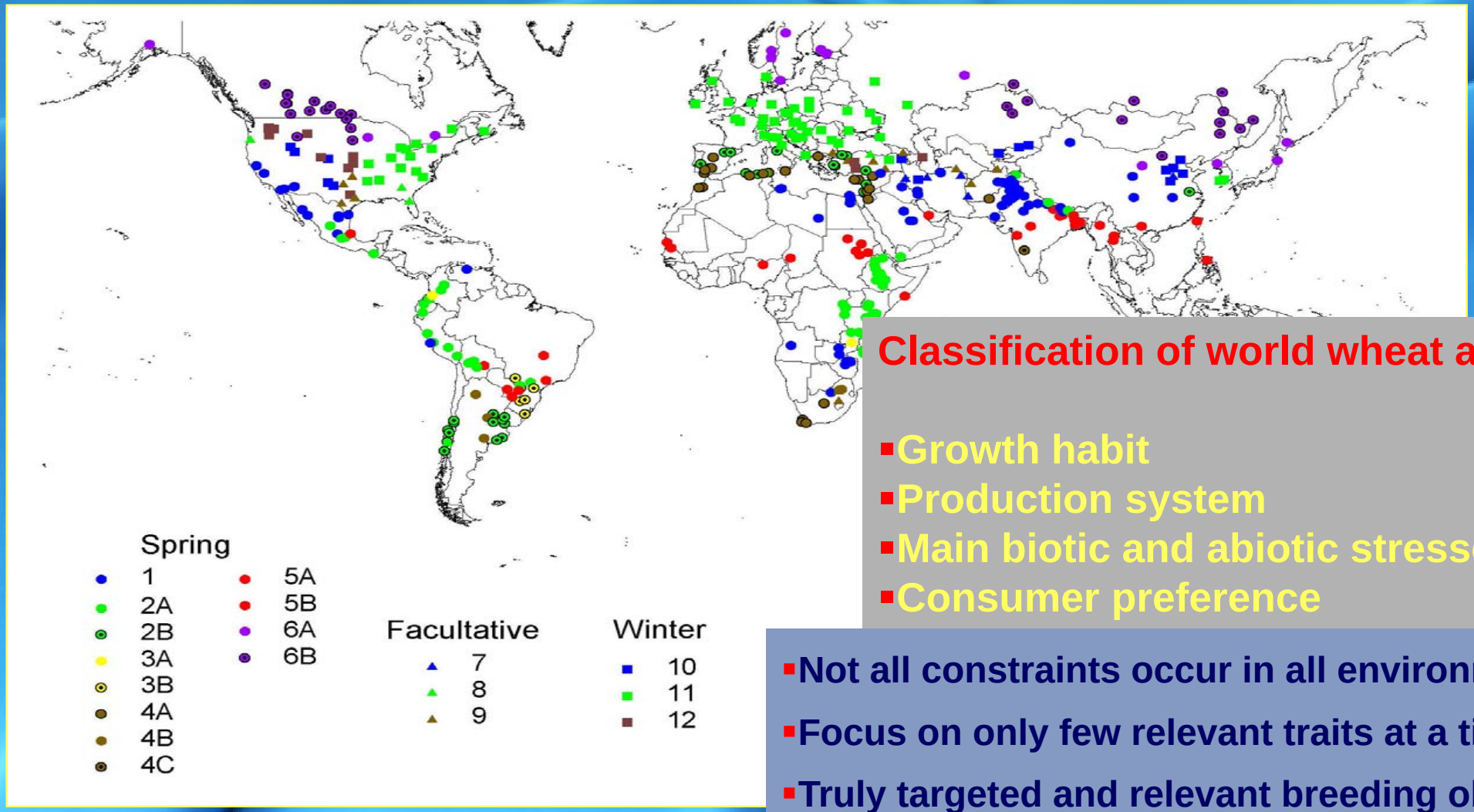
Economics & Strategic Social Sciences Research

Multi-disciplinary …
… Several crop options

Global breeding…

… rational organization of activities

The mega-environment (ME) concept



Classification of world wheat area by:

- Growth habit
- Production system
- Main biotic and abiotic stresses
- Consumer preference

- Not all constraints occur in all environments
- Focus on only few relevant traits at a time
- Truly targeted and relevant breeding objectives

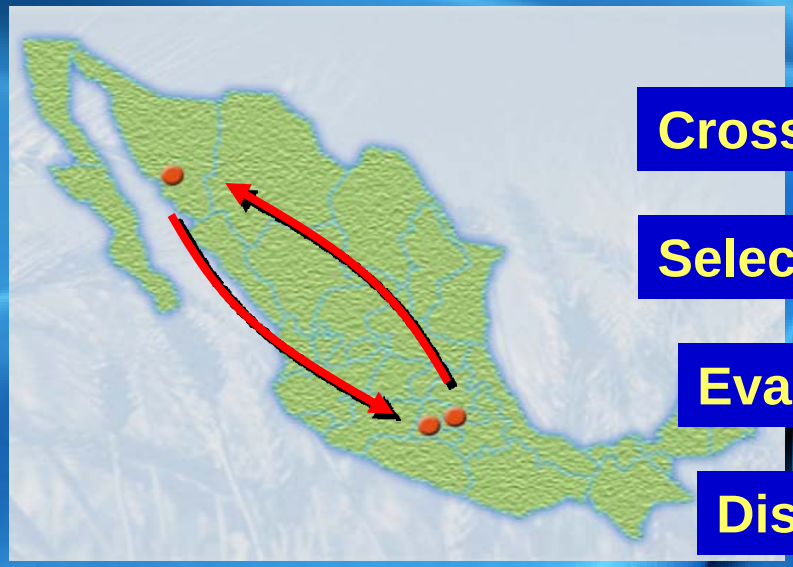
Spring wheat mega-environments

Mega-Environment	Water Supply	Major Diseases	Major Constraints	Grain Color
ME 1 Temperate	**Irrigated**	LR, YR	Terminal heat Some salinity	White
ME 5 Hot		LR, YR, HLB	Heat permanent Some salinity	White
ME 2 Normal Soils	**High Rainfall**	LR, YR, ST, FHS	Sprouting	Red
ME 3 Acid Soils		LR, YR, ST, FHS	Acid Soils Sprouting	Red
ME 4 Drought	**Low Rainfall**	LR, YR, FG, Nem.	Drought Some heat	White/red
ME 6 High Latitude		LR, YR	Photoperiod Sensitivity	red

Facultative/winter wheat mega-environments (breeding out of TURKEY)

Mega-Environment	Water Supply	Growth Habit	Vernalization Requirements	Cold Tolerance
ME 7	Irrigated	FACULTATIVE	Low	Low
ME 8	High Rainfall	FACULTATIVE	Low	Low
ME 9	Drought	FACULTATIVE	Low	Low
ME 10	Irrigated	WINTER	Strong	Strong
ME 11	High Rainfall	WINTER	Strong	Strong
ME 12	Drought	WINTER	Strong	Strong

General breeding scheme

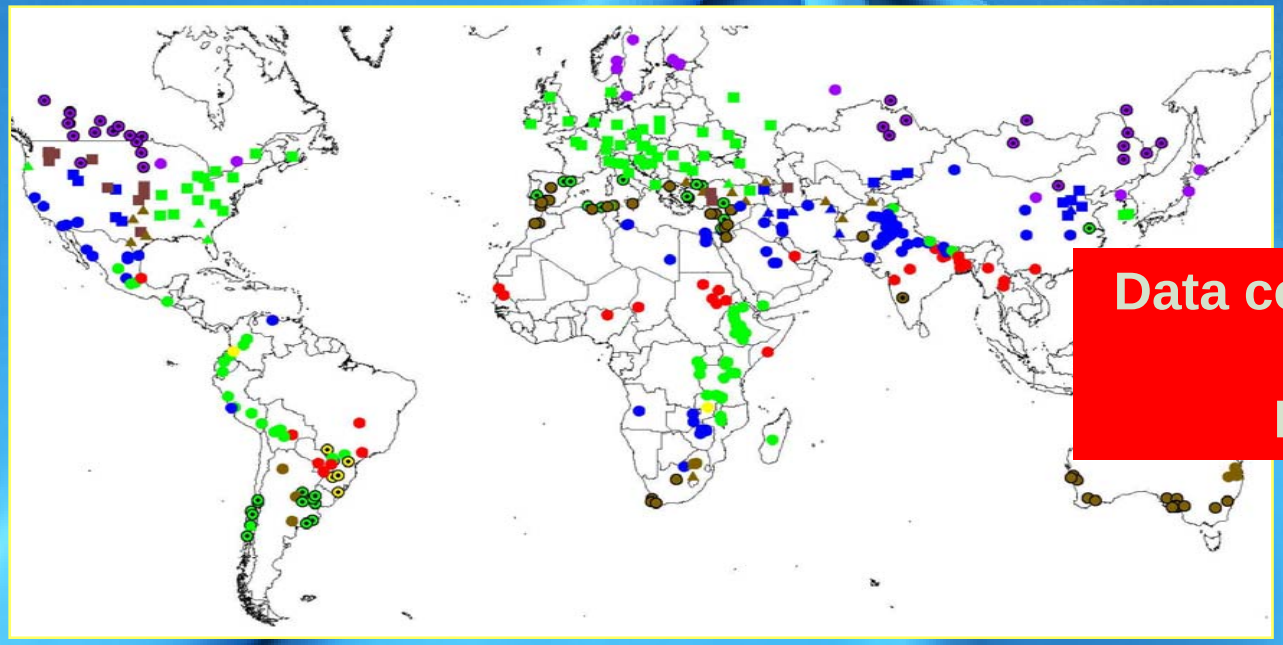


Crossing

Selection

Evaluation of fixed lines in Mexico

Distribution of improved material through IWN



Data collection & interpretation of worldwide
Multi-location testing

Crossing

Choice of Parents

- Widely adapted major variety
- Performance in Mexico under different water regimes
- Global or Regional performance in IN
- Agronomic, Disease and Quality data from Mexico and worldwide
- Collaborator/outreach information
- Donors of important traits/genes
- Use of novel material for enhancing genetic diversity

Crossing

Crop	Number Crosses/year
Bread Wheat Intensive	3000-5000
Bread Wheat Rainfed drought	2000-2500
Durum Wheat All	2500-3000
Triticale All	800-1300

General selection scheme

Traits

Cross → F1

F2

F3

F4

F5

- Disease resistance
- Good agronomic type
- ME-specific adaptative traits

- High yield potential (preliminary)
- Disease resistance
- Good agronomic type
- ME-specific adaptative traits
- Acceptable general quality attributes
- Uniformity

F6

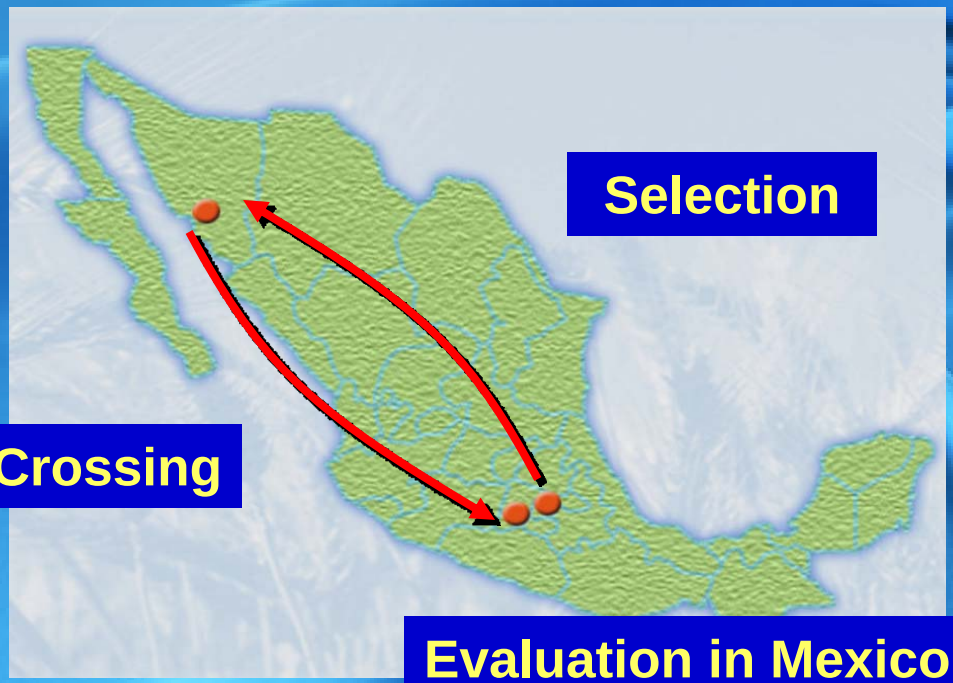
F7

F8

Replicated/Multi-Environment yield testing,
Selection of candidates for INs

General breeding scheme

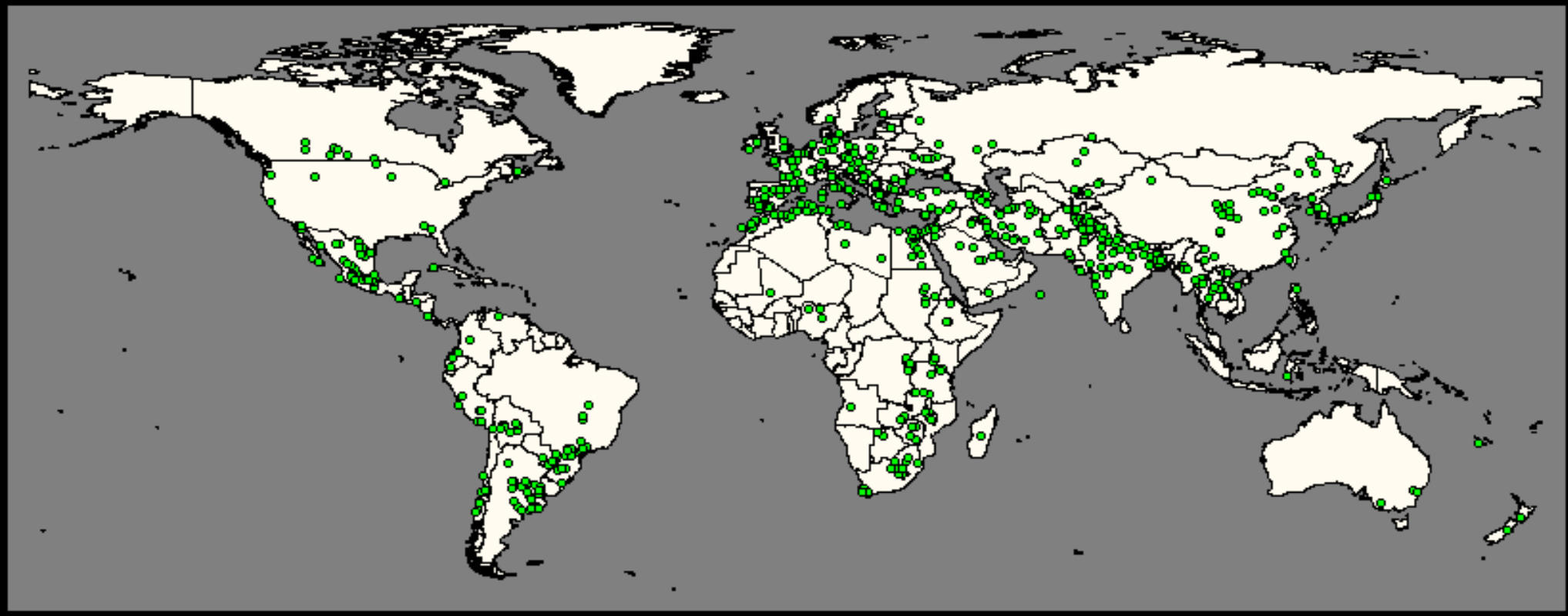
Competitive advantage:



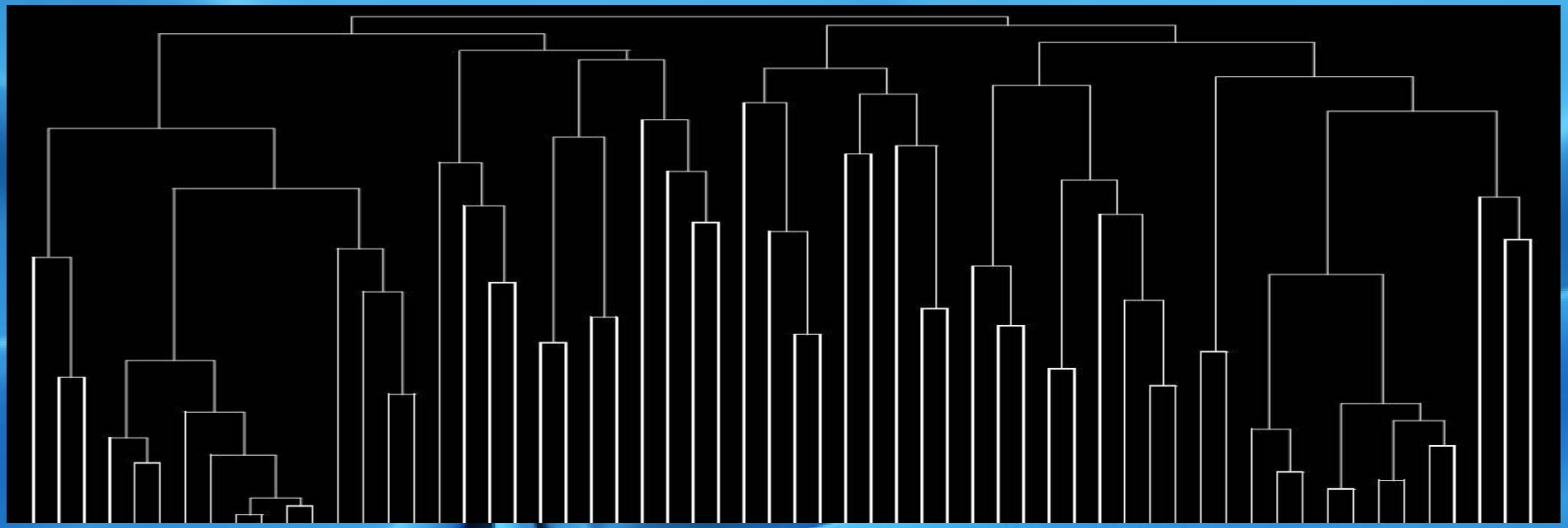
2 crops/year

4 years,
from cross….
…to identification of promising lines

CIMMYT trial locations



Drip irrigation to generate moisture stress in Cd. Obregon



Group	1	2	3	4	5	6	7
Stress generated in Mexico	Gravity continuous stress	Drip Terminal stress	Gravity No Stress	Drip Continuous stress	Heat and terminal moisture stress	Drip Moisture stress pre-flowering	Gravity terminal stress
International Sites	Brazil Spain Algeria Bolivia Pakistan	No sites	No sites	Saudi Arabia Argentina South Africa Egypt Canada	Zimbabwe Iran Pakistan	Nepal Brazil Pakistan Iran Canada	Iran Bangladesh Saudi Arabia Spain Afghanistan

Associations among stress environments, irrigation systems and international test sites (bread wheat)

Old & new challenges

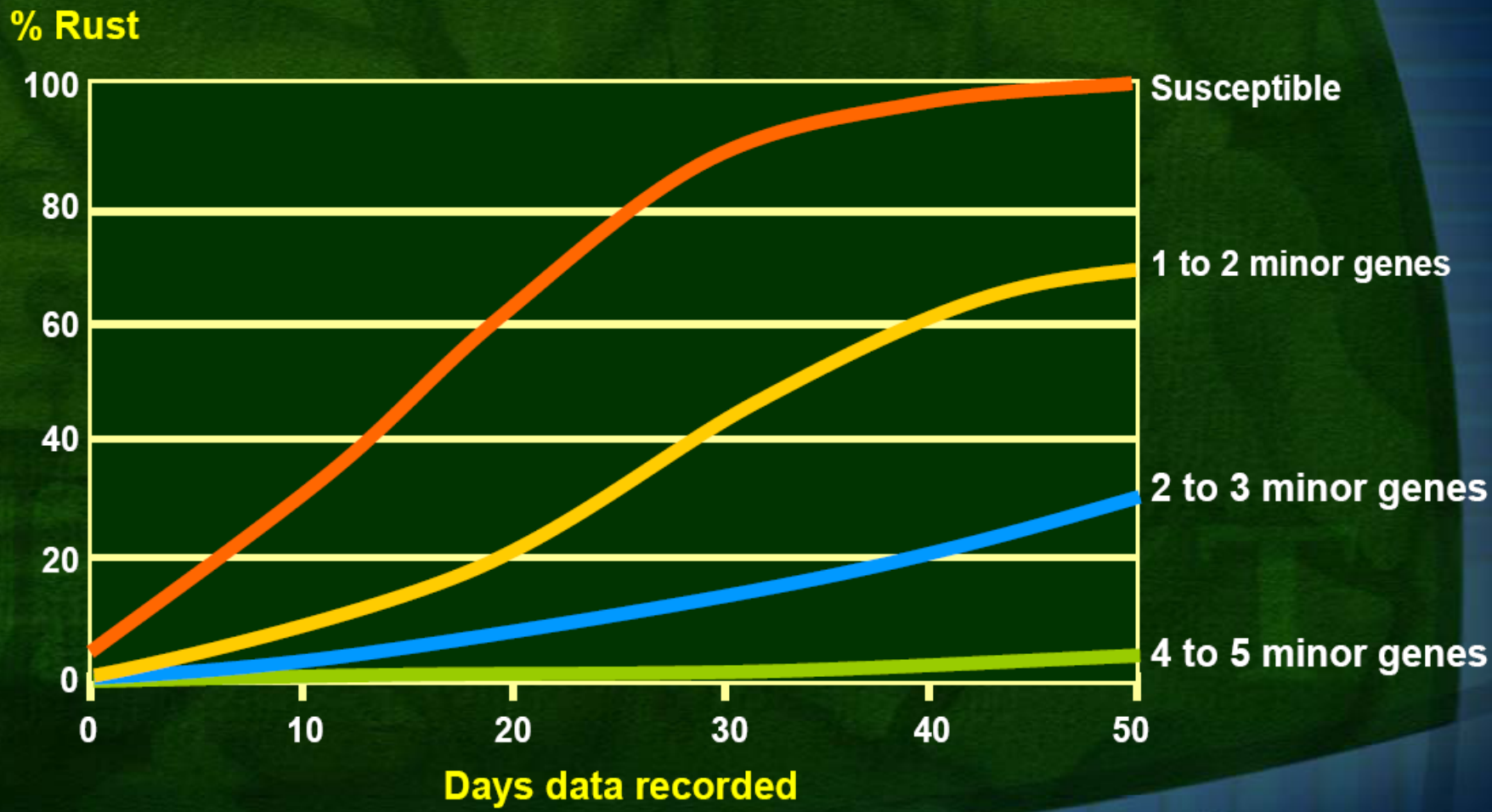
Breeding for durable rust resistance

- ✓ Monitor worldwide changes in races
- ✓ Identify new genetic variability for resistance
- ✓ Accumulate resistance genes that cannot be defeated by pathogen
- ✓ Prepare for replacement of major varieties

Types of Resistance

- Race-specific ≈ Monogenic ≈ Major genes ≈ Hypersensitive *(Boom & Bust)*
- Non race-specific ≈ Polygenic ≈ Minor genes ≈ Slow rusting/ Partial *(Durable)*

Race-Nonspecific Resistance to Leaf and Stripe Rusts in Wheat: Genetic-Phenotypic Model



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Maintaining Genetic Diversity

- Necessary for a long-term durability
- High in CIMMYT germplasm: over 10 slow rusting genes present
- Characterized genes:
  - Leaf rust: *Lr34*, *Lr46* and *LrPrl1*
  - Yellow rust: *Yr18*, *Yr29*, *YrPrl1* and *Yr30*

CIMMYT
International Maize and Wheat Improvement Center

锈病持久抗性研究：Ravi Singh

- 广适应品种 X 锈病持久抗性材料
- 与广适应品种回交1-2次
- 大分离群体
- 选择与广适应品种类似、同时又具有持久抗性的后代

Old & new challenges

Breeding for drought tolerance through improving water use efficiency

1. Deep planting
2. Alien resources

Screening for tolerance to moisture stress

抗旱育种: Richard Trethowan

- Deep planting
- Yield trial
  - Full irrigation
  - Reduced irrigation
  - No irrigation

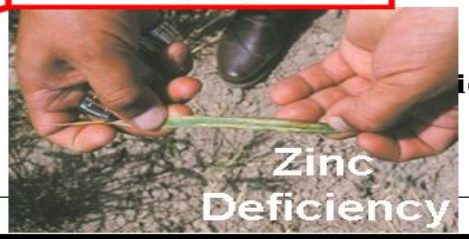
Old & new challenges

Breeding for drought tolerance

Through improving root health + Nutrient use efficiency

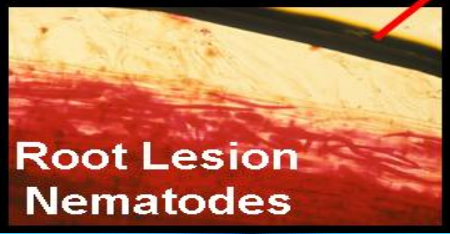
Abiotic Stresses

Moisture Stress	Temperature Extremes	Nutrient Stress - Macro/Micro & pH Extremes
• Terminal • Pre-Anthesis • Residual Moisture • Reduced Irrigation • General Low Rainfall • Shallow, Marginal, Infertile, Eroded Lands	• Heat Stress Humid • Heat Stress Dry • Cold Stress • Cold Stress – Late Frost	• P and N Deficiency/ Efficiency • Deficiency (e.g. Zinc)



Combined Stress

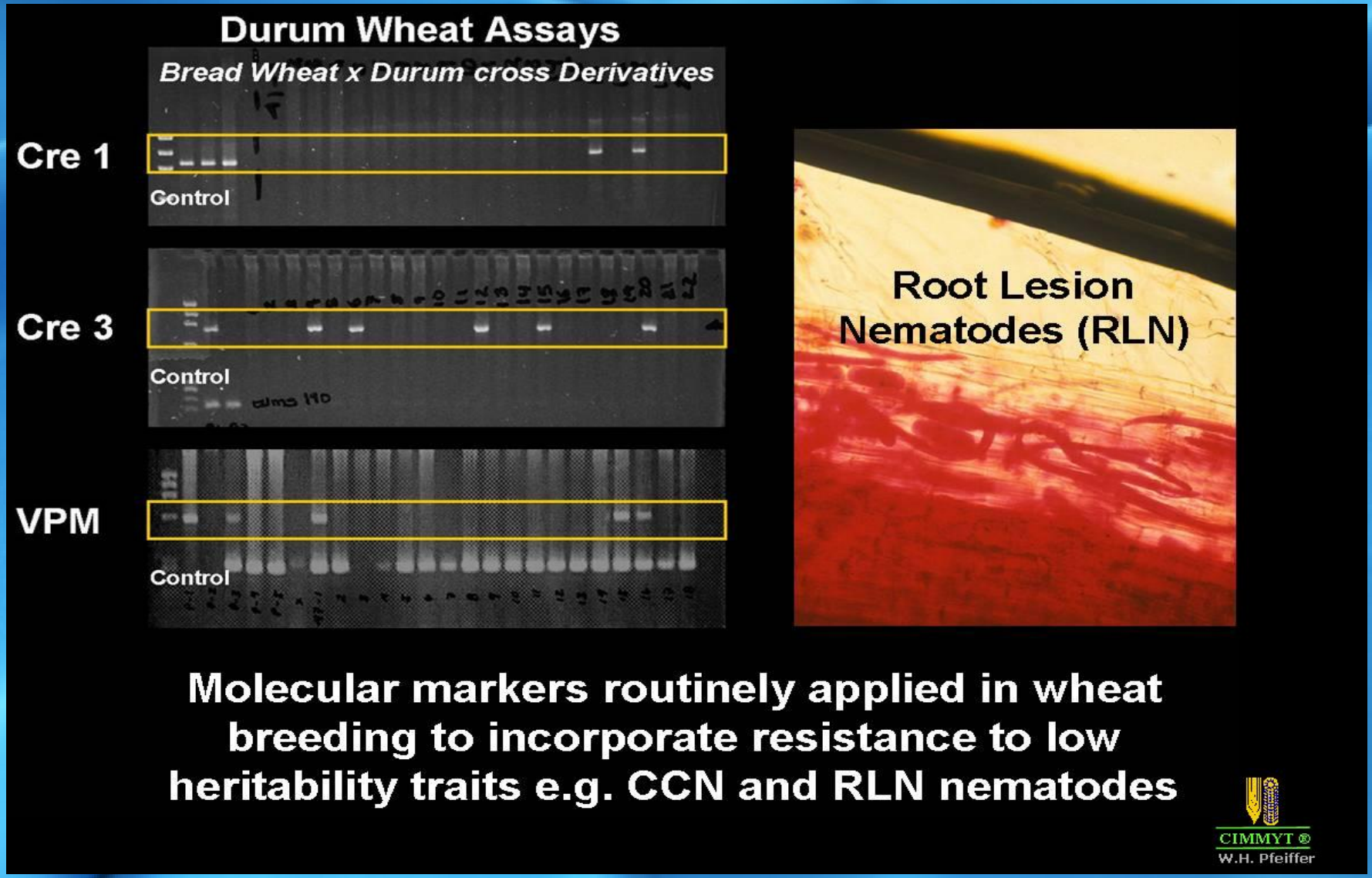
Biotic Stresses



New challenges, new tools

Drought tolerance through better root health

Use of molecular markers



Make crosses and conduct selection in Cd. Obregon


Thank you!