

Research Development and Innovation in Wheat Value Chains for Oilseeds, Oil and Fats, Grains and Rice: Status and Outlook

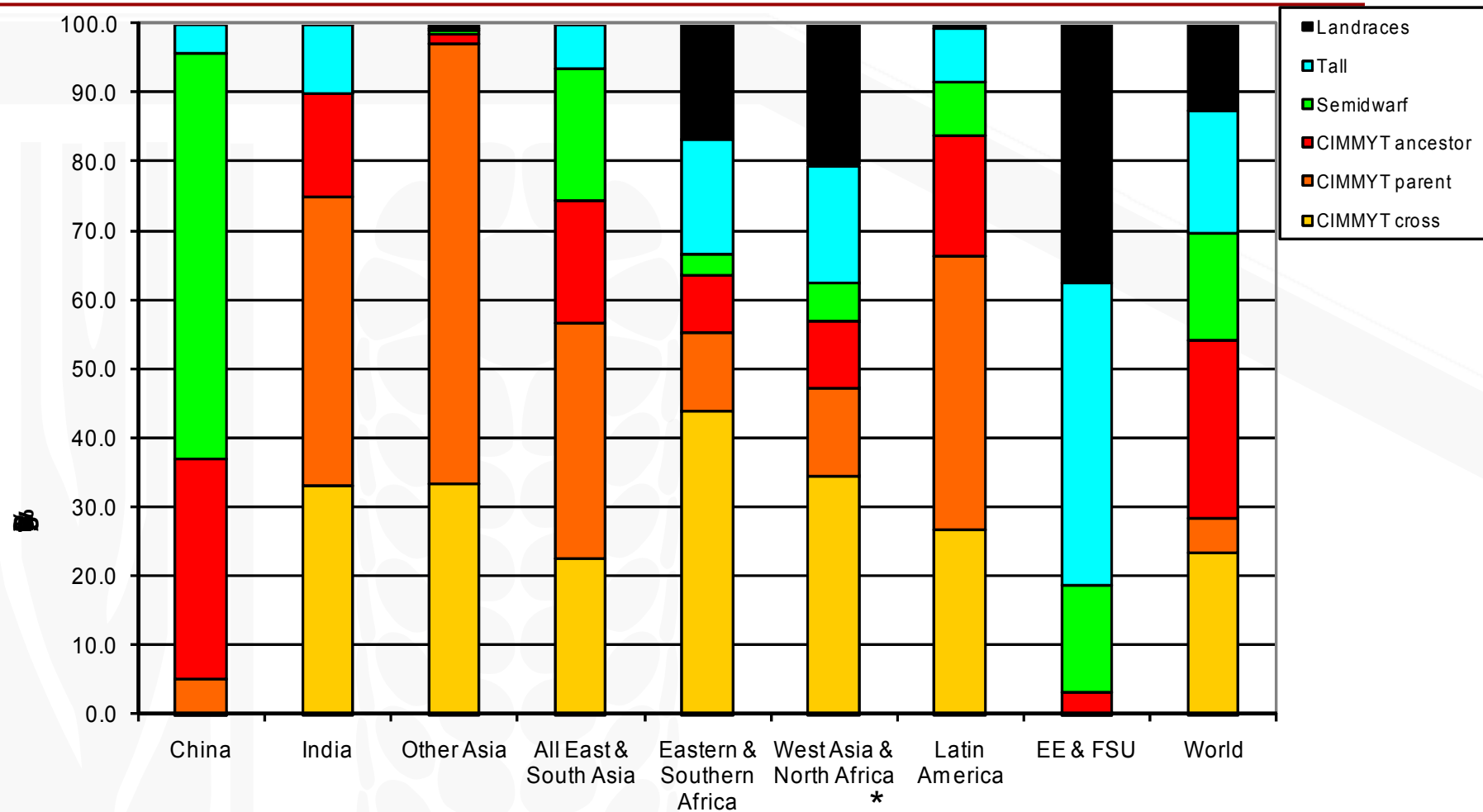


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November 6, 2009

What is CIMMYT

- ❑ One of 15 Int. Agric Res. Centers with HQ in Mexico
- ❑ Mission: Alleviate poverty through improved maize and wheat systems
- ❑ Employs around 90 IRS and 500 NRS
- ❑ Annual budget 52 million US\$
- ❑ Donors:
 - Intern. Organizations (WB, UNDP, FAO, IFAD, etc)
 - AID Agencies and Client Countries, (Bra, Col, Per)
 - Philanthropic Organizations (RF, BMGF)
- ❑ Started Green Revolution – Norman Borlaug

Area sown to all wheat in the world

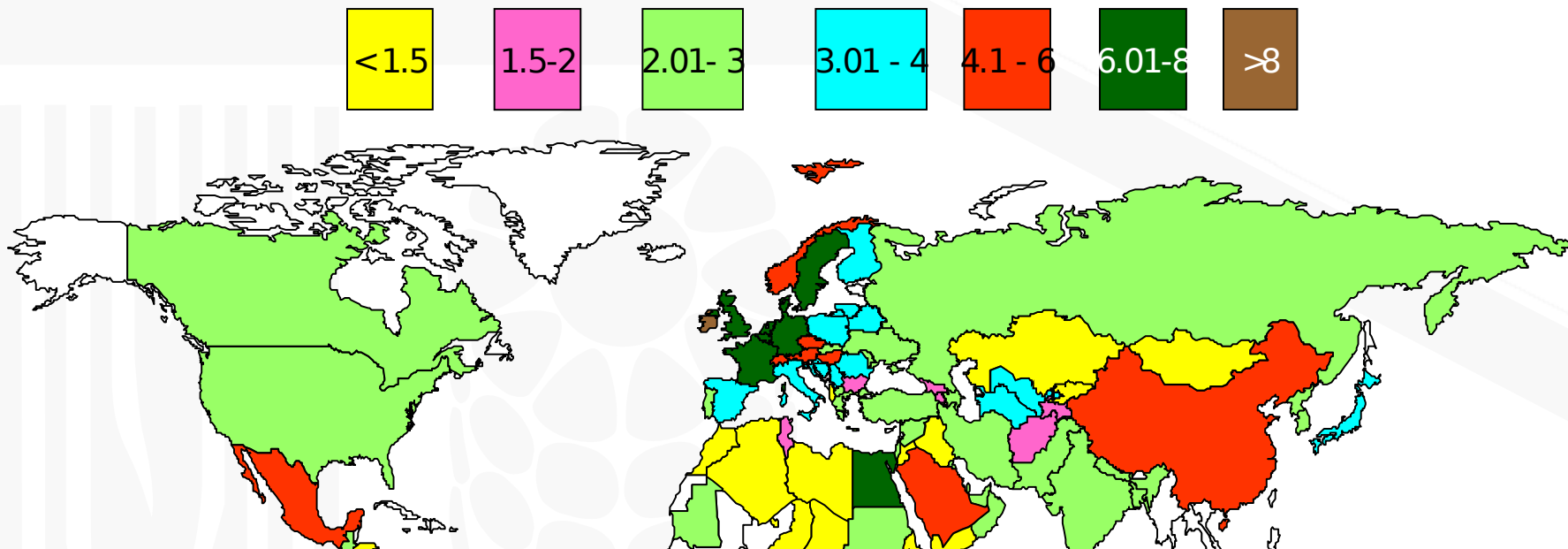


*CWANA joint ICARDA-CIMMYT Wheat Improvement Program

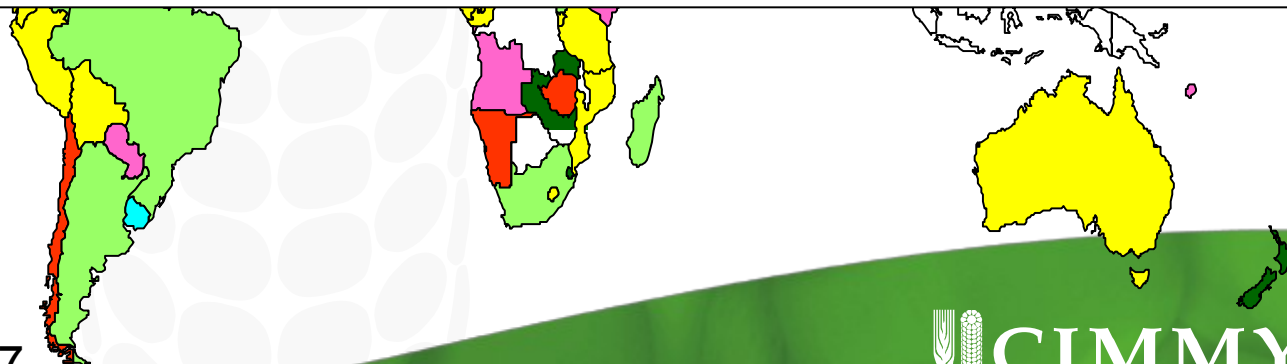
Why Wheat Research Matters

- ❑ **22% of all calories come from wheat**
- ❑ **In 7 of last 10 years consumption > production**
- ❑ **Wheat is the most traded cereal crop – though only 10% of all wheat is exported**
- ❑ **Excellent way to transport water**

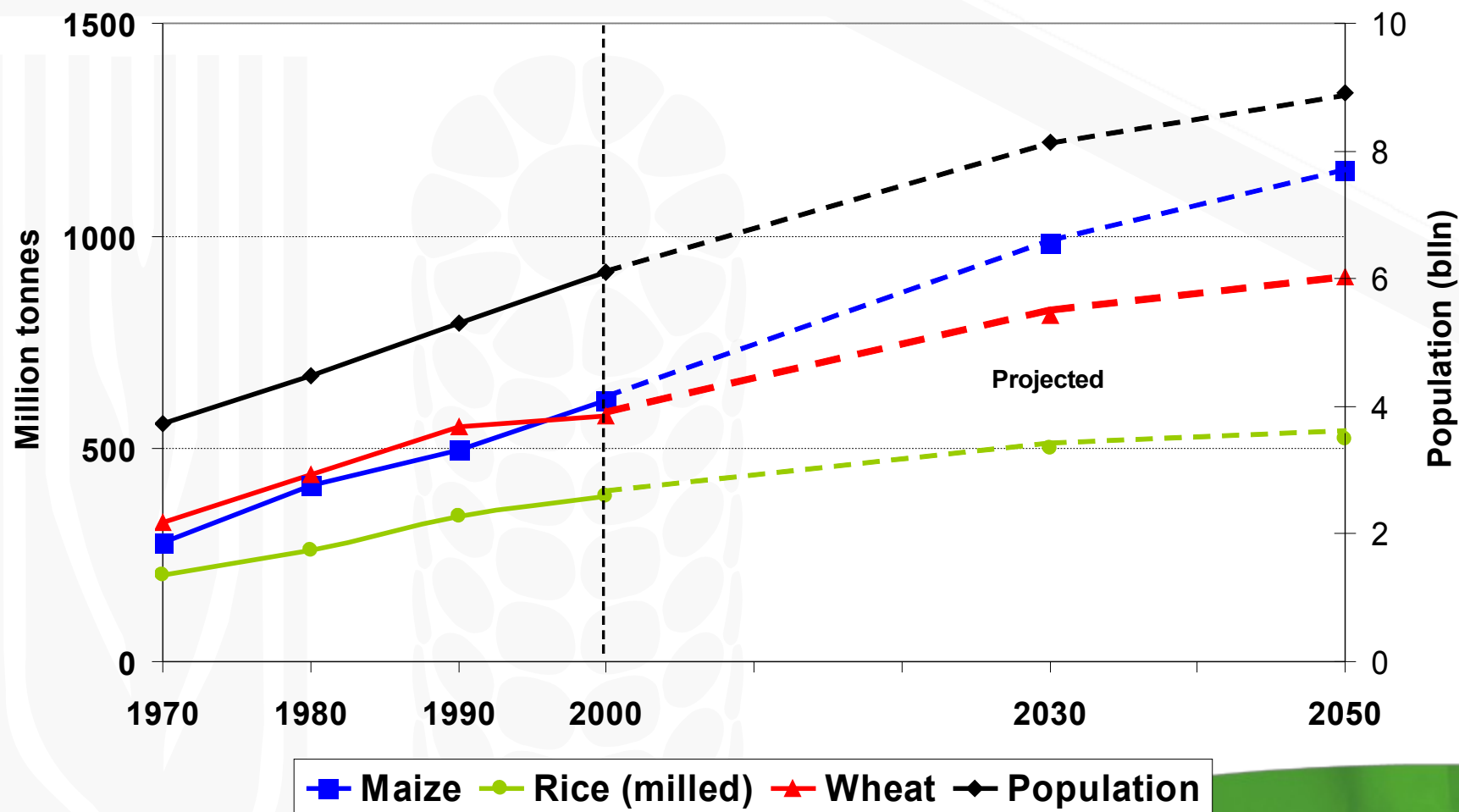
Average Wheat Grain Yield 2007 = 2.8t/ha



Average Wheat Grain Yield 2050 = 5 t/ha

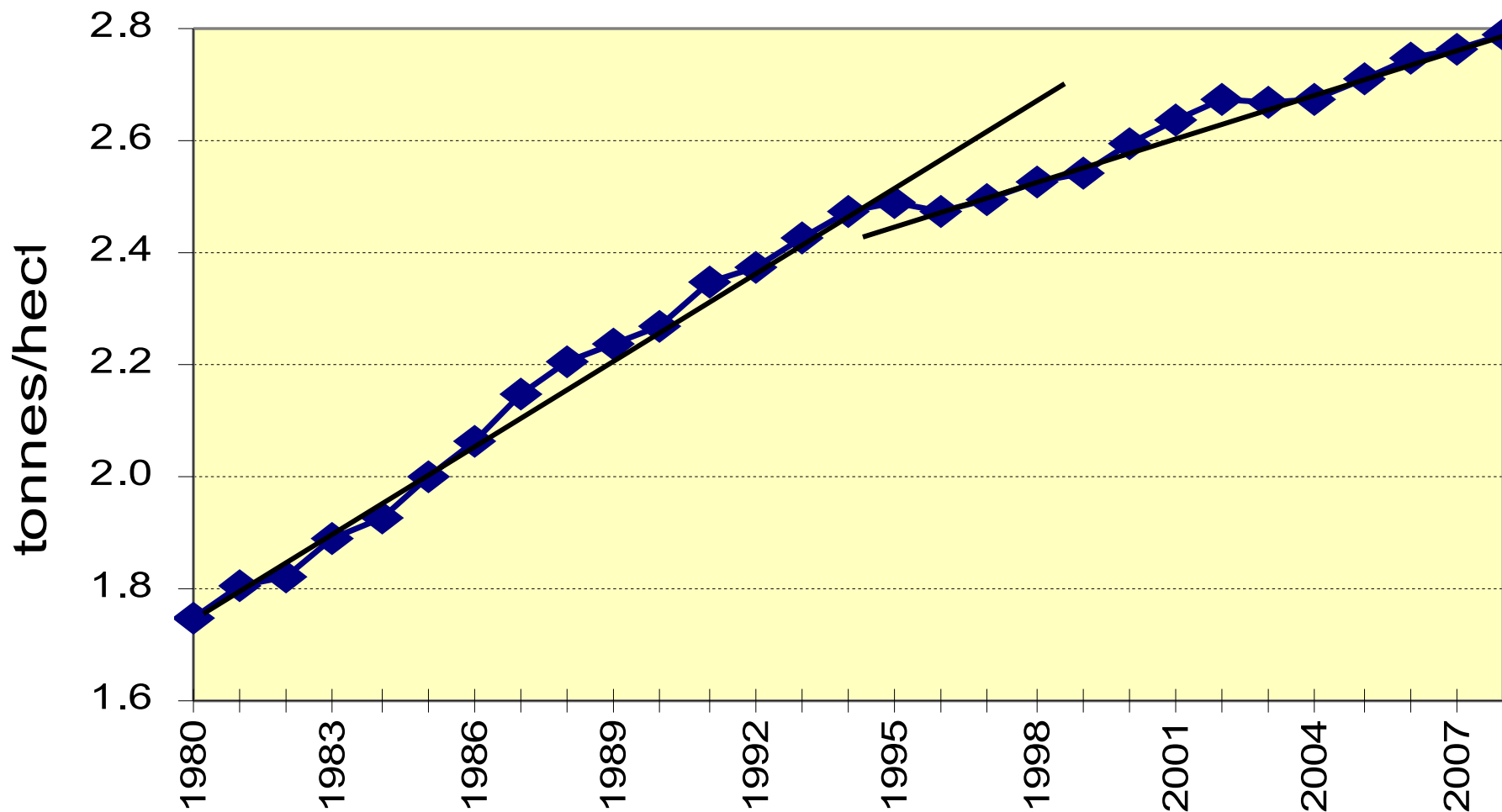


World demand for wheat, maize and rice 1970-2050



WORLD WHEAT YIELD TRENDS

(5 Year Moving Average - tonnes/ha)

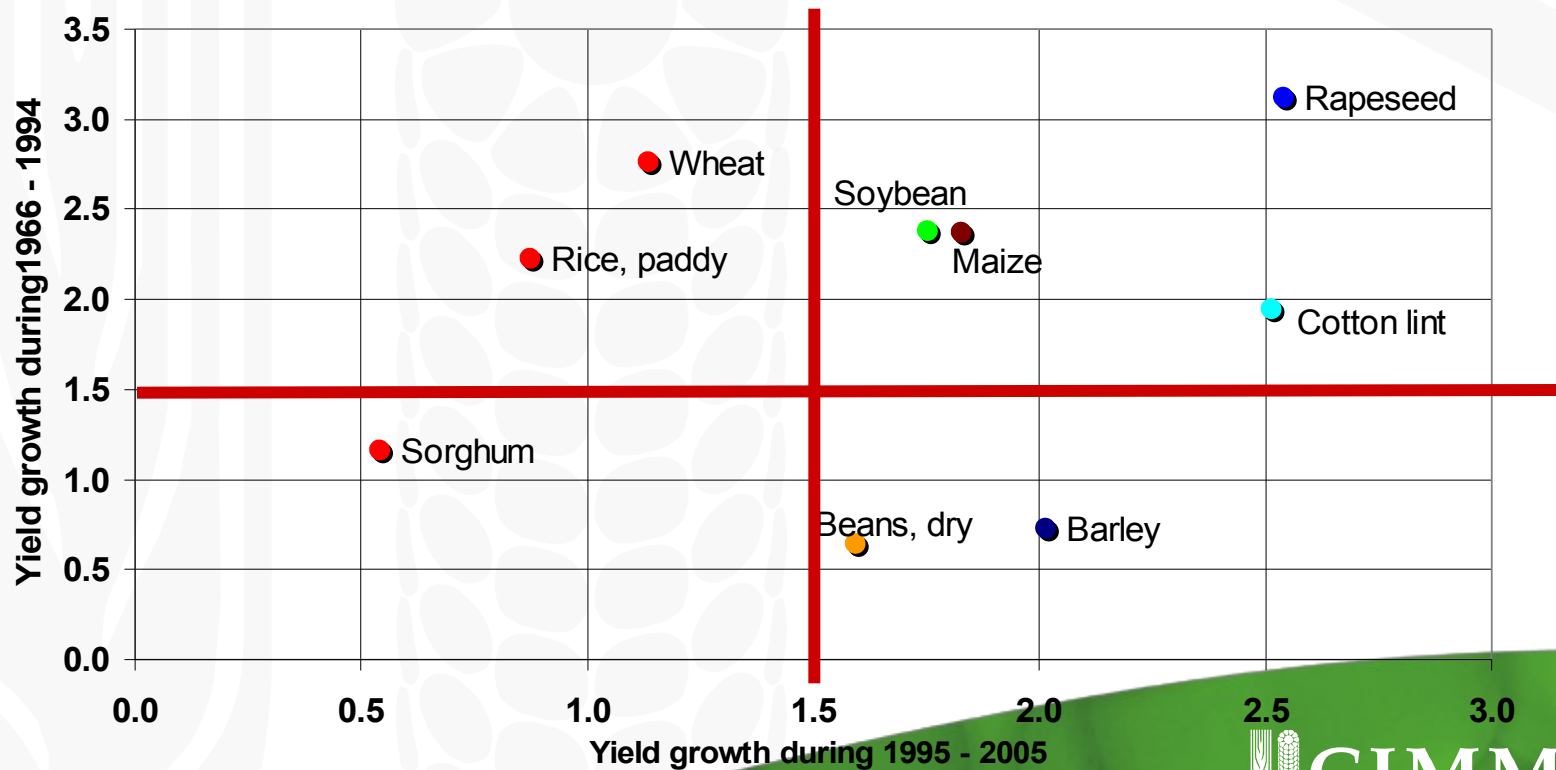


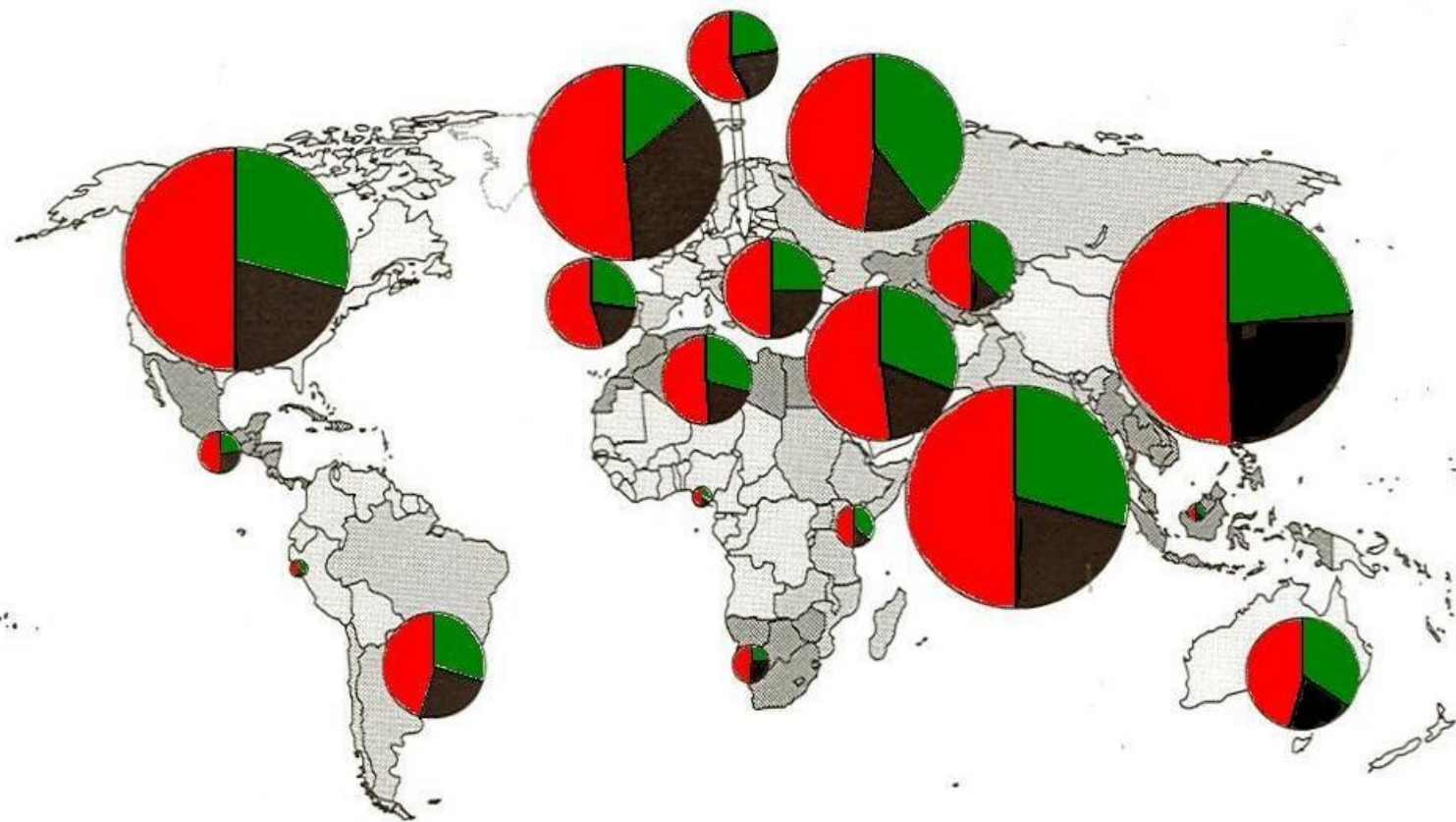
Source: Chudleigh, 2008

Another Inconvenient Truth:

Facts and not hype on yield gains with GM-crops (cotton, maize, rapeseed and soybean)

Yield growth differentials by period (1966-94 cf. 1995-2005) for
major food and cotton crops in developing countries





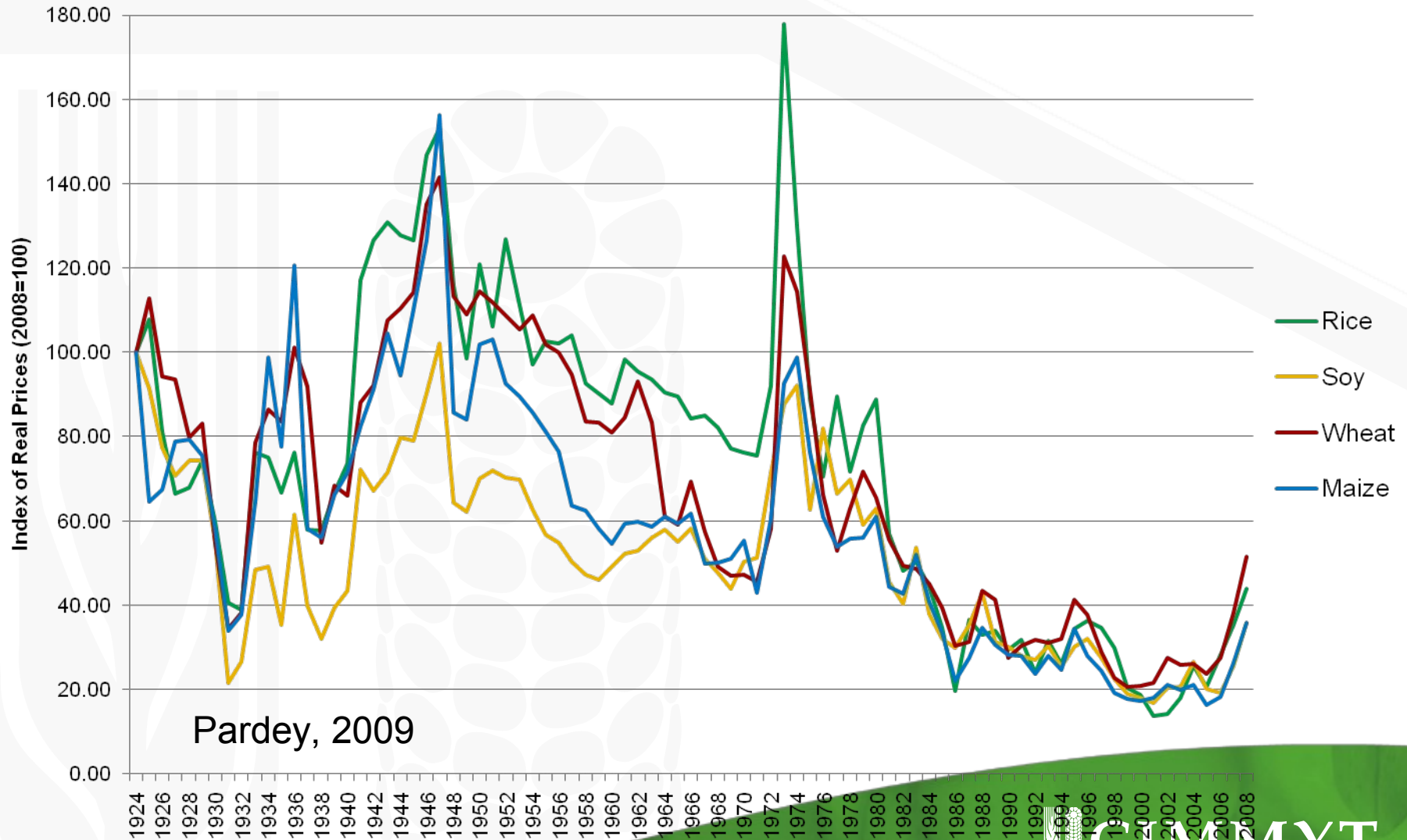
Without crop
Protection
50%

Due to crop
Protection
22%

Losses
28%

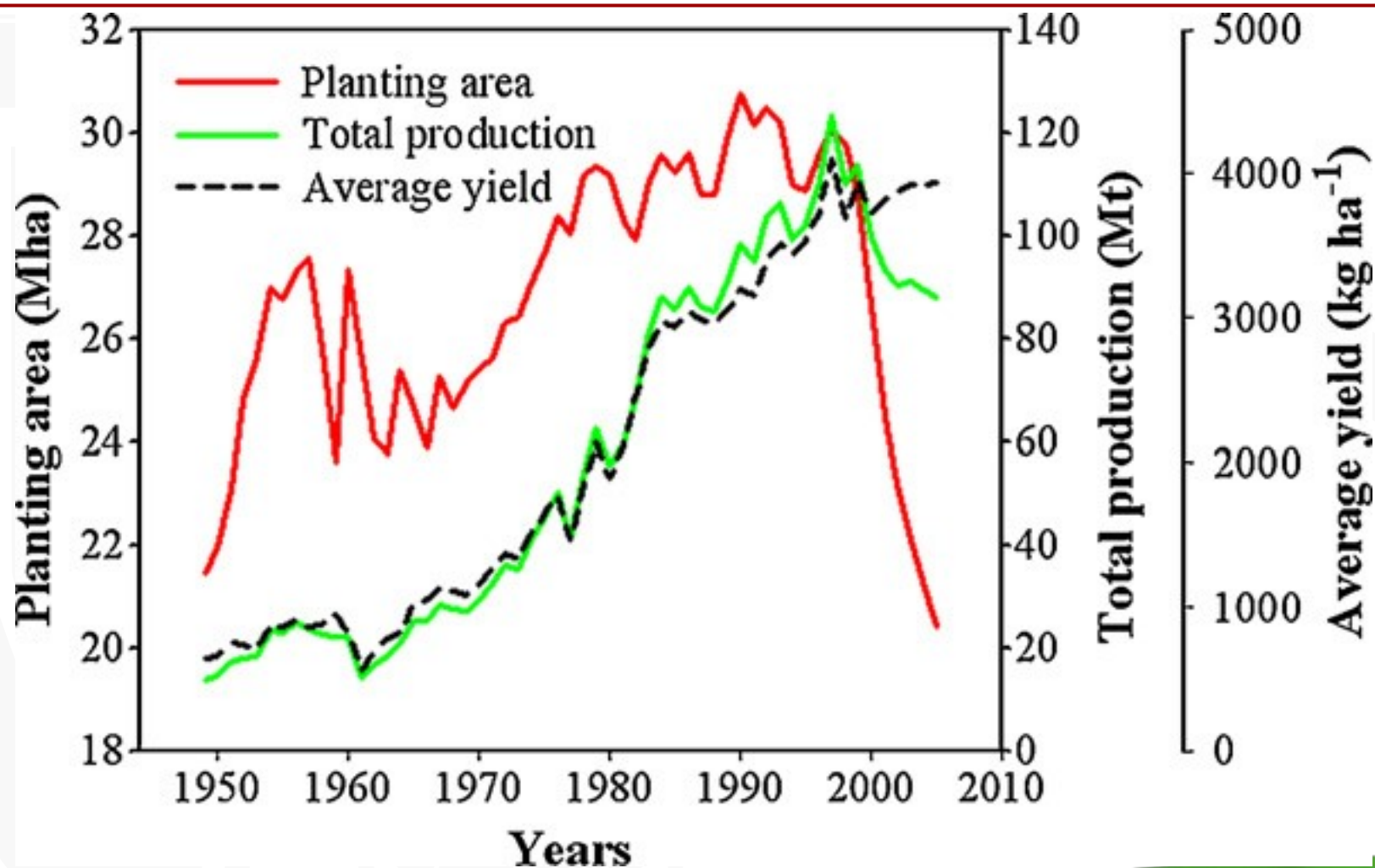
Estimated contribution of crop protection (mechanical, biological and chemical) to wheat production for 2001 – 03. Modified after Oerke 2006.

Real U.S. Commodity Prices, 1924-2008 (Deflator = CPI)



Pardey, 2009

Wheat Statistics for China from 1945 - 2005



Income from Wheat and Barley

<u>Source</u>	<u>billion US\$</u>	<u>%</u>
Breeder Seed / Royalties	0.3	0.02
Certified Seed	2.1	0.14
Growers – grain for food	66.0	5
Grain traders – elevators	68.0	5
Millers	71.0	4
Bakers, Brewers, Distillers	572.0	39
Retailers	686.0	47
Total	1445.4	

Source: Syngenta, 2008

Global investments in crop research

- ❑ Wheat < 350 mln US\$
- ❑ Maize > 1500 million US\$
- ❑ Investments in maize focused – few global players
- ❑ Wheat smaller investments scattered across many cooperators – mainly public funding
- ❑ Public – private sector cooperation – access private sector technology

Wheat producers again challenged with a “new environment”

Text book wisdom for wheat production valid?

- ❑ Global Climate Change
- ❑ New diseases - epidemiology
- ❑ Soil temperature –microflora –SBD
- ❑ New agronomic practices RCT
- ❑ Environmental concerns
 - Pollution from Agriculture GHG
 - Nutrient use efficiency (2/3 of N lost)
- ❑ Organic farming
- ❑ **Research and not subsidies will address these problems**



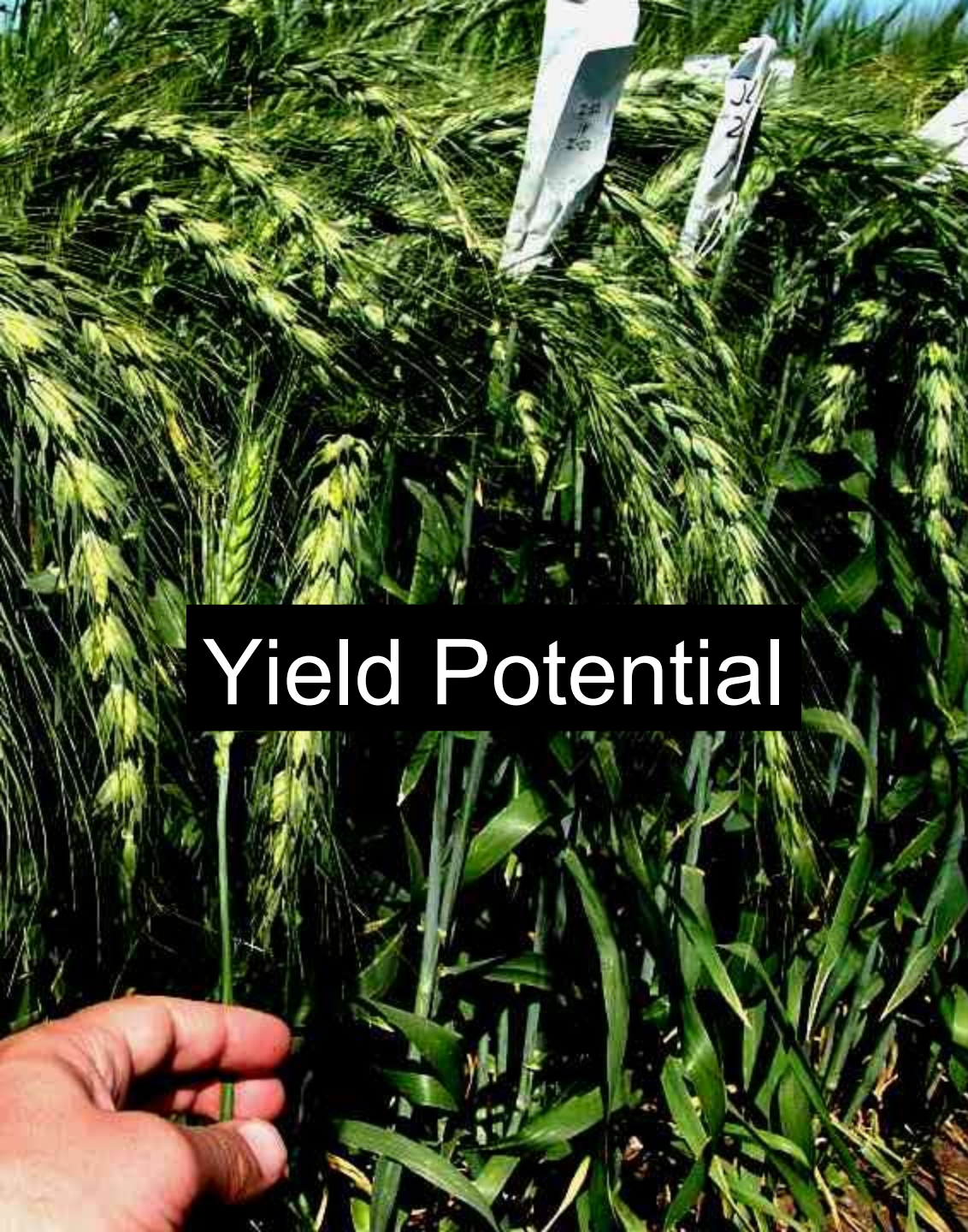
Global Wheat Breeding Priorities

Core breeding priorities CIMMYT

- Grain yield potential and yield stability
- Water and nutrient use efficiency
- Heat tolerance
- End use quality
- Adaptation to conservation agriculture
- High Zn and Fe concentration

Focused diseases and pests

- ❑ **Rusts: Stem (Black), Stripe (Yellow) and Leaf (Brown)**
- ❑ **Septoria leaf blight**
- ❑ **Fusarium head blight**
- ❑ **Spot blotch**
- ❑ **Tan spot**
- ❑ **Karnal bunt**
- ❑ **Helminthosporium leaf blight**
- ❑ **Wheat Blast (emerging disease)**



Yield Potential



Strategies to increase yield in wheat

Combining photosynthetic capacity, optimal partitioning to yield, and lodging resistance is expected to have synergistic impacts on yield in farmers' fields (Reynolds et al., 2009).

PHOTOSYNTHETIC CAPACITY:

- Rubisco efficiency
- C4 metabolism
- Canopy/spike photosynthesis

YIELD MAINTENANCE:

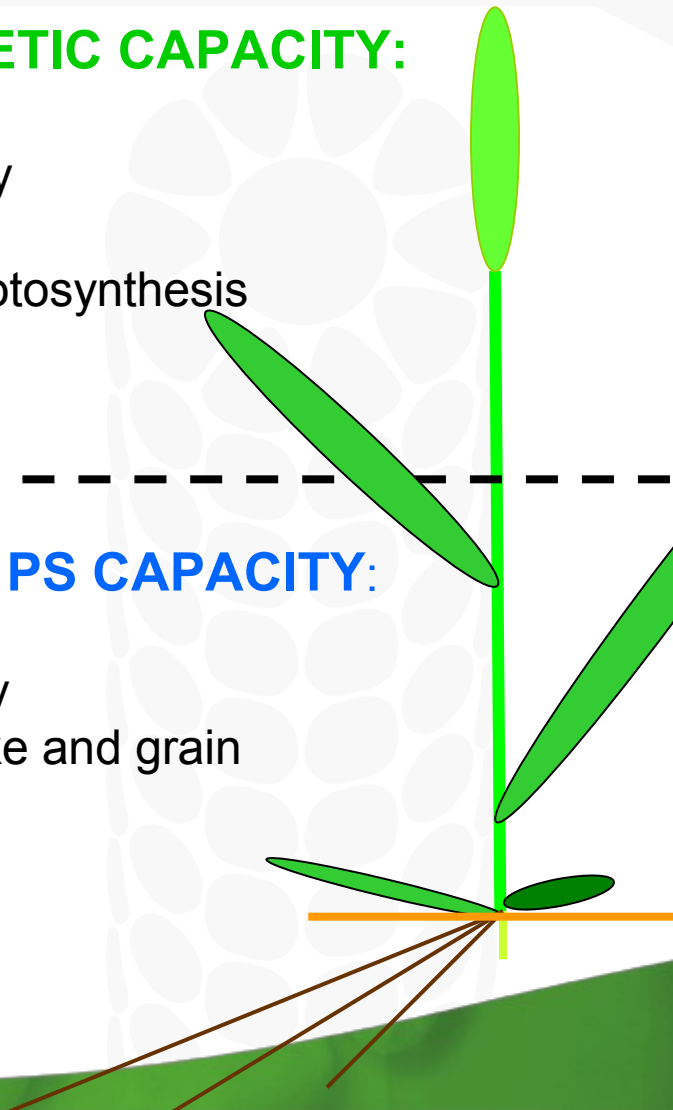
- Lodging resistance
- (biotic stress resistance)

UTILIZATION of PS CAPACITY:

- Optimal phenology
- Partitioning to spike and grain

GENETIC RESOURCES

- Explore Triticae tribe
- Strategic crossing
- Genetic basis of yield traits
- Marker assisted breeding



Hybrid Wheat

- ❑ Increase yield potential
- ❑ Increase tolerance to abiotic stresses
- ❑ Increased yield stability
- ❑ Faster reaction to changes (disease, quality)
- ❑ GM approaches
- ❑ Attracts private sector funds – global interest

Enhancing Drought Tolerance

Utilizing all available variability for drought tolerance

▣ AABBDD Synthetic derivatives



T. durum
AABB



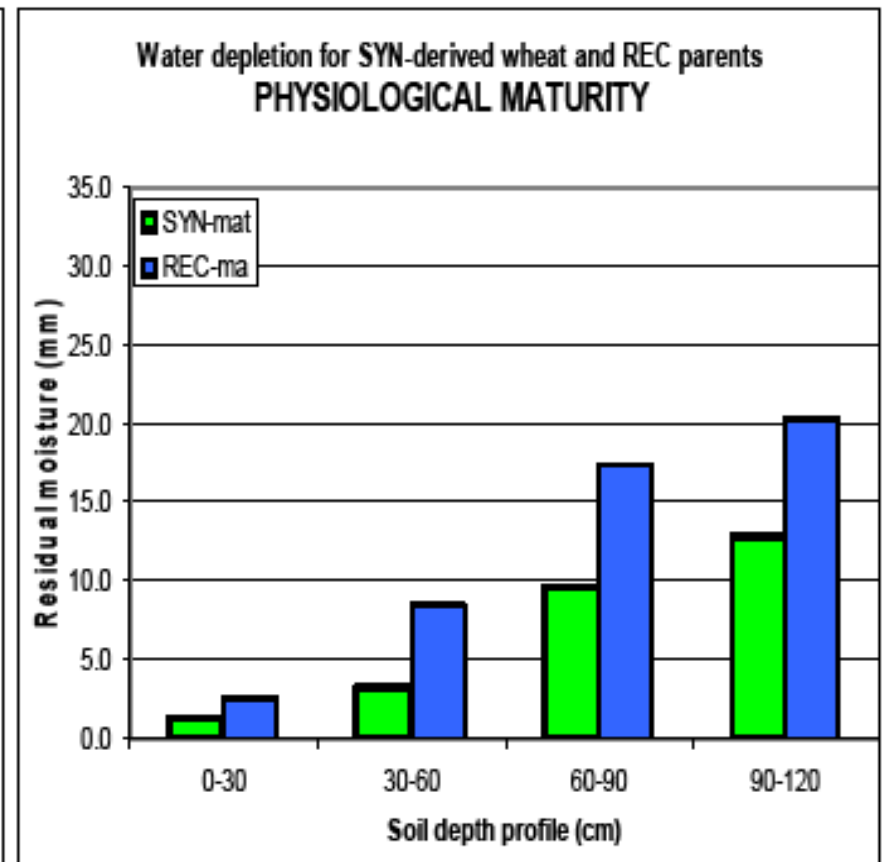
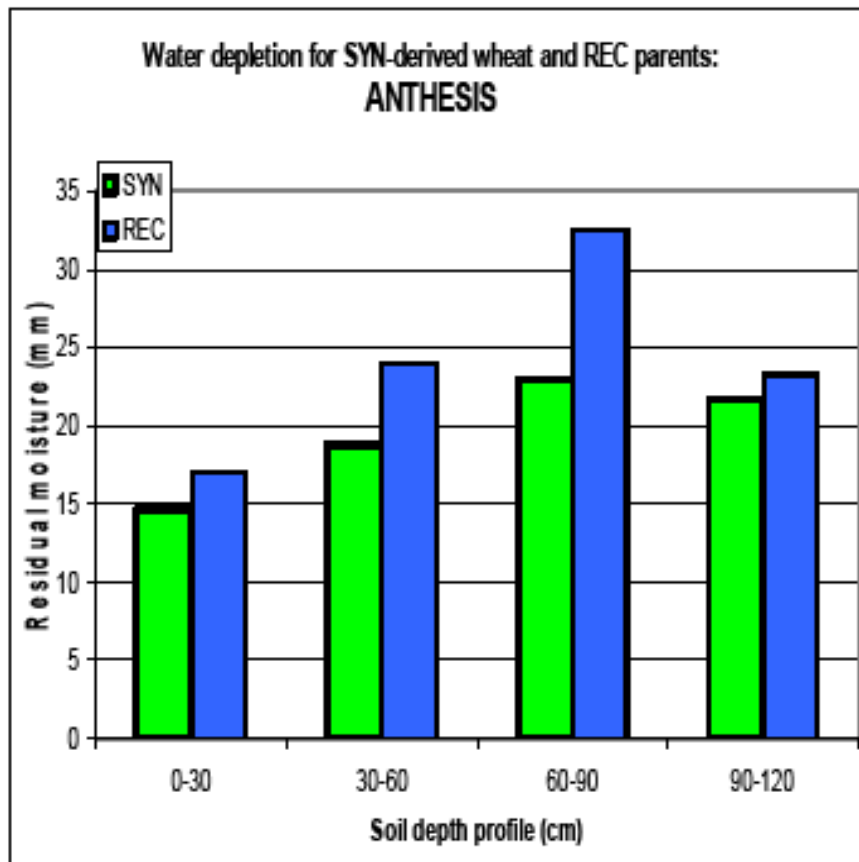
T. tauschii
DD



Hexaploid Synthetic
AABBDD



SYN-derived lines extract more water from deeper in soil profile



Humans Water and Wheat

- 1000 l water = 1 kg wheat
- 1800 l water = 1 kg rice
- 10 000 – 15 000 l water = 1 kg beef
- Annual Water Consumption of 1 Indian citizen =
Water to produce 10 kg wheat
- North Africa and Near East Countries import on
average 10 mln tons of wheat / year =
Water consumption of the entire human population
in 3 years

Heat Stress

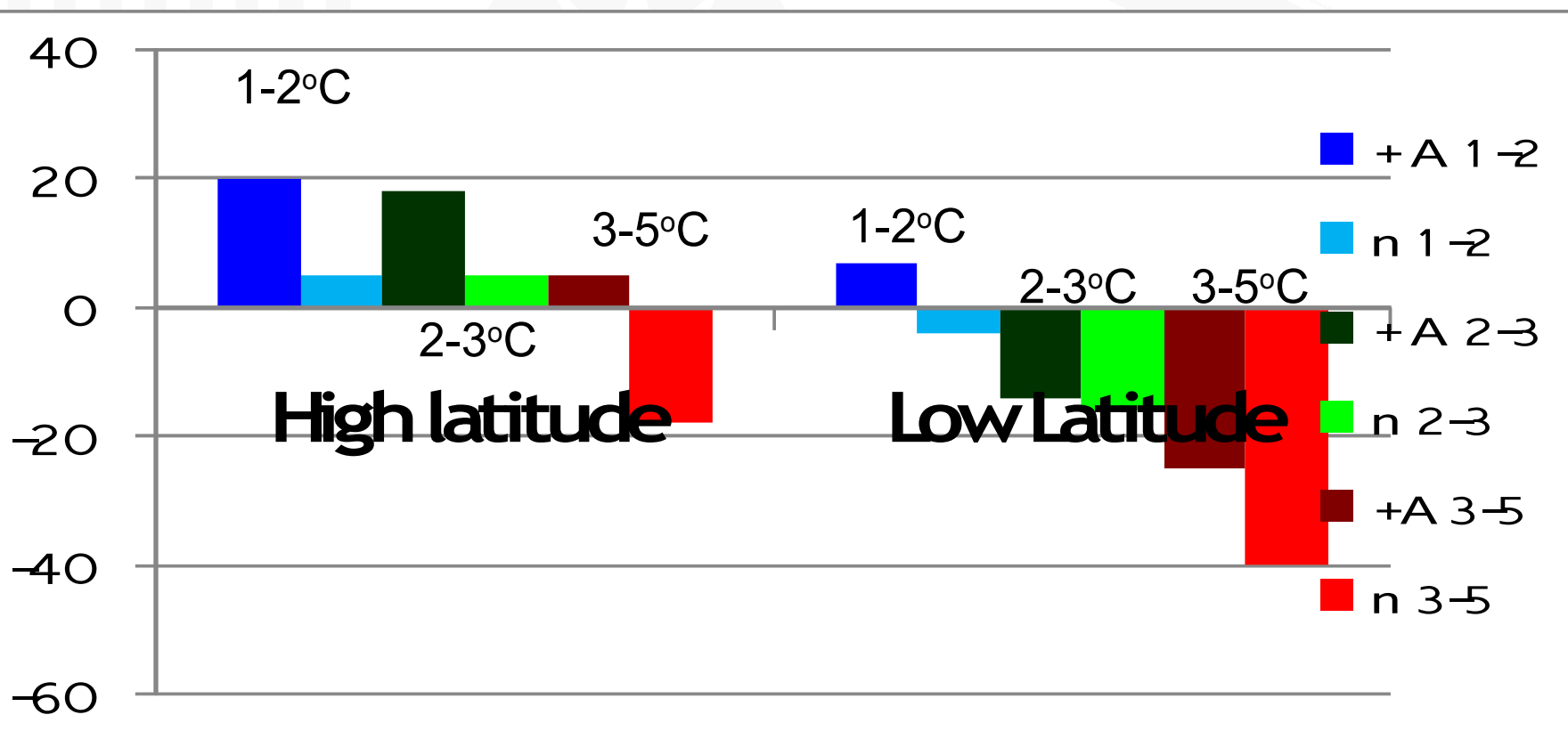
- ❑ Heat stress may cause as much yield loss as drought
- ❑ High night temperatures
- ❑ 90% of all irrigated wheat in LDC

Climate change: Impact on agriculture and costs of adaptation (IFPRI, 2009)

- ❑ Irrigated wheat yields in 2050 reduced by around 30%; irrigated rice yields reduced by 15% in developing countries
- ❑ Prices increase in 2050 by 90% for wheat, 12% for rice, and 35% for maize, on top of already higher prices
- ❑ At least US\$7 billion a year are necessary to improve agricultural productivity to prevent adverse effects

Average change of wheat yield with (A) and without (n) adaptive measures (sowing date, cultivar, irrigation) in response to temperature increase (1-2, 2-3, 3-5) in high and low latitude

% Yield change

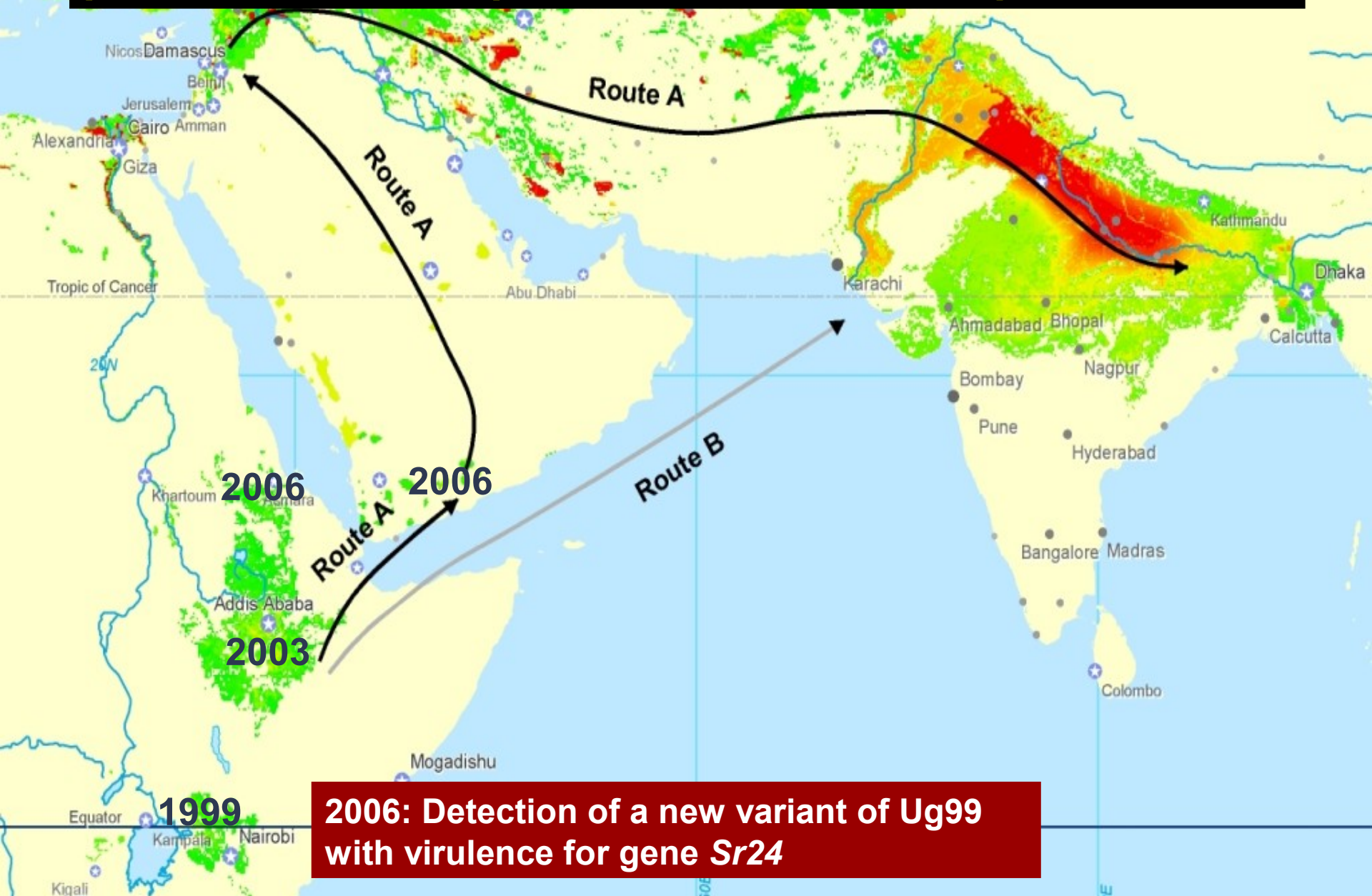


Ug 99 Stem Rust

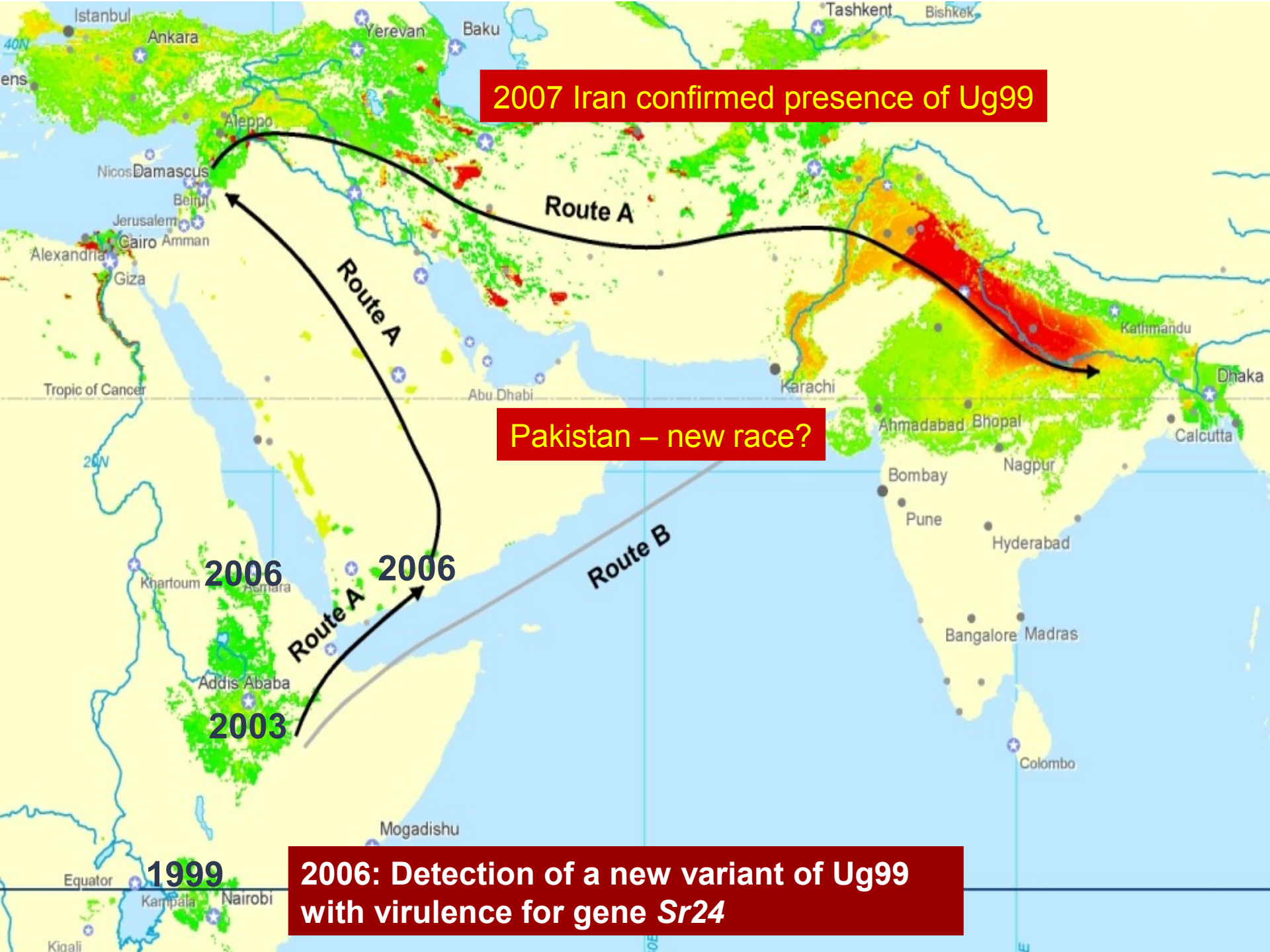
- Historically most damaging wheat disease
- Controlled through resistance for last 50 years
- Little investments – very little knowledge
- As of 2008 highest priority for wheat improvement in LDC



Migration routes towards South Asia based on predominant wind patterns and historical precedent



2006: Detection of a new variant of Ug99 with virulence for gene *Sr24*



2007 Iran confirmed presence of Ug99

Pakistan – new race?

2006: Detection of a new variant of Ug99 with virulence for gene *Sr24*

Usefulness of designated genes for resistance to Ug99

<i>Bread Wheat</i>	5, 6, 7a*, 7b, 8a, 8b, 9a, 9b, 9f, 15, 16, 18, 19, 20, 23, 28*, 29, 30, 41, 42	
<i>T. aestivum</i>		
<i>T. turgidum</i>	2, 9d, 9e, 9g, 11, 12, 13*, 14*, 17	
<i>T. monococcum</i>	21, 22, 35	
<i>T. timopheevi</i>	36, 37	
<i>T. speltoides</i>	32, 39	
<i>T. tauschii</i>	33, 45	Blue = immediate use
<i>T. comosum</i>	34	Yellow = virulence known to occur in other races
<i>T. ventricosum</i>	38	
<i>T. araraticum</i>	40	
<i>Thinopyrum elong.</i>	24, 25*, 26, 43	Green = effective (incl. moderate levels)
<i>Th. intermedium</i>	44	
<i>Rye (S. cereale)</i>	27*, 31, R(1A.1R)* Sha7, Tmp*	Red = not effective

Quality / Nutrition

- Nearly all Wheat in LDC consumed as food
- Urbanization / convenience food
 - → more processed wheat products
 - → Industrial quality / consistency
- Increasing income → specific quality attributes
- For CIMMYT, Industrial quality high priority → core traits including Micro-nutrients (Zn, Fe, Harvest Plus)

NON FOOD USES OF WHEAT

Starch

- **Functional foods.** Sweetener, emulsifier, foaming and thickening agent in foods soups, beverages, ice cream
- **Pharmaceuticals and cosmetics.** Vehicle of active ingredients
- **Biofuel.** Ethanol
- **Films/coatings/bags.** Packaging and coatings to protect flavor, shelf life
- **Polymers/resins/adhesives.** Plasticity, adhesiveness and flexibility to polymers

Gluten

- **Functional foods.** Emulsifier, foaming, and thickening agent, milk replacer
- **Cosmetics.** Moisturizers, foaming agents, conditioners
- **Films/coatings/bags.** Packaging and coatings to protect flavor, shelf life
- **Polymers/resins/adhesives.** Plasticity adhesiveness and flexibility to polymers
- **Inks.** Reduce drying of pen tips
- **Detergents.** Stabilize enzyme-added detergents
- **Rubber products.** Flours to reinforce non-tire rubber

Germ

- **Oil.** Policosanols (waxy alcohols) reducing cholesterol and HDL in humans
- **Oil.** Antioxidants (cell conservation), pharmaceuticals, and cosmetics

Wheat Straw. Ethanol, other biofuels, construction panels

Wheat trading & end-use quality

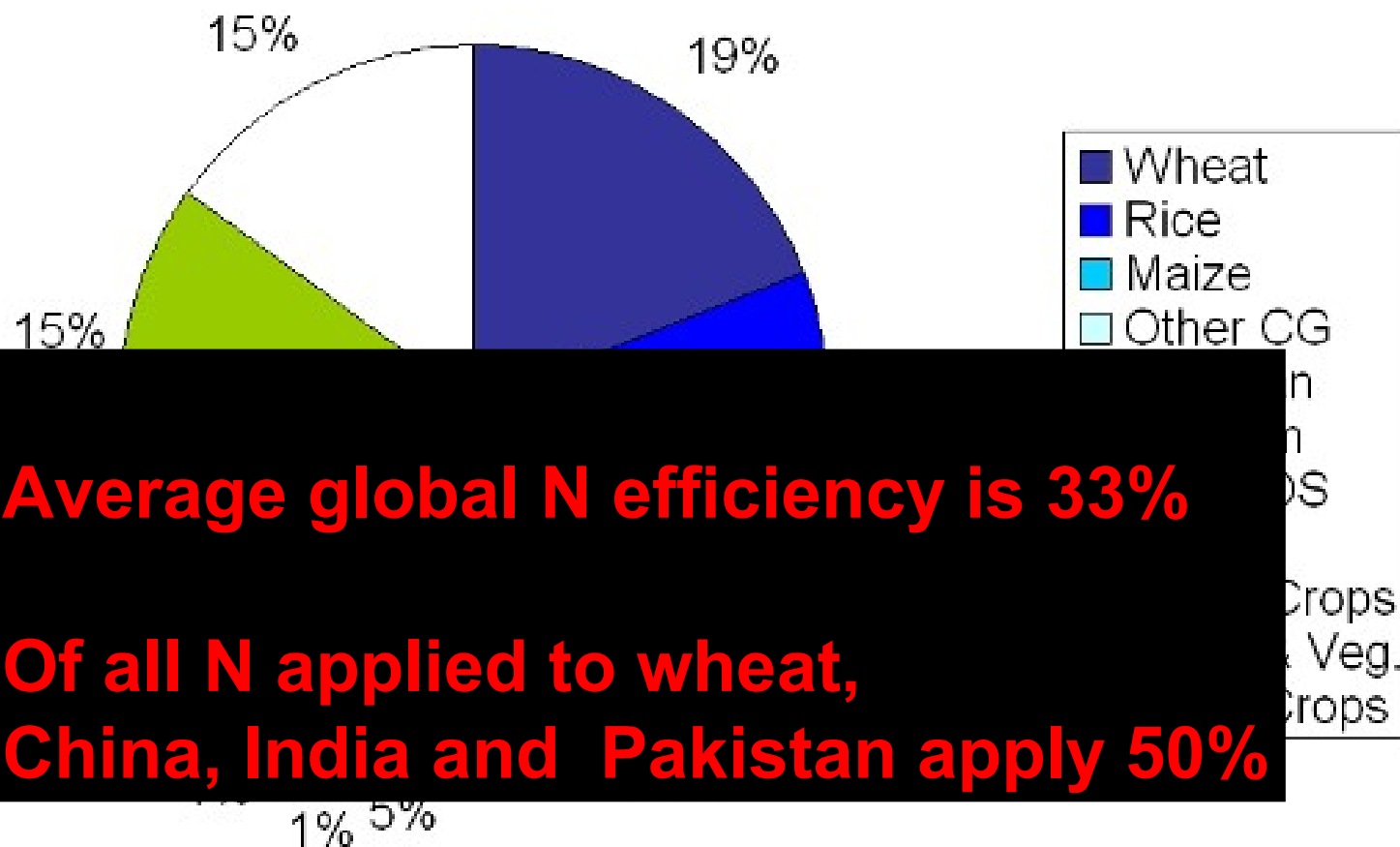
Exporters*	Target markets							
	Yeasted breads	Flat breads	Steamed breads	Cookies & pastry	Flour Noodles	Pasta	Feed	Industrial Non-food
Canada	+	+	-	+	+	+	+	-
Australia	+	+	+	+	+	+	+	-
USA	+	+	-	+	+	+	+	+
EU	+	-	-	+	-	+	+	+
Argentina	+	-	-	-	-	+	-	-
Kazakhstan	+	+	-	-	-	-	+	-
Ukraine	+	+	-	-	-	-	+	-
India	-	+	-	-	-	+	-	-

**Wheat exports are based mostly on grain quality. Therefore, the main objective of NARS is breeding for specific quality traits.*

Micro Nutrient Deficiency and Human Nutrition - Harvest Plus®

- ❑ Hundreds of million people suffer from Zn-deficiency
- ❑ 3.5 billion suffer from Fe deficiency
- ❑ Focus on T. Dicoccum and dicoccoides
- ❑ Lines with enhanced Fe and Zn (> 20% over currently grown cultivars) in yield trials in India and Pakistan in 2010

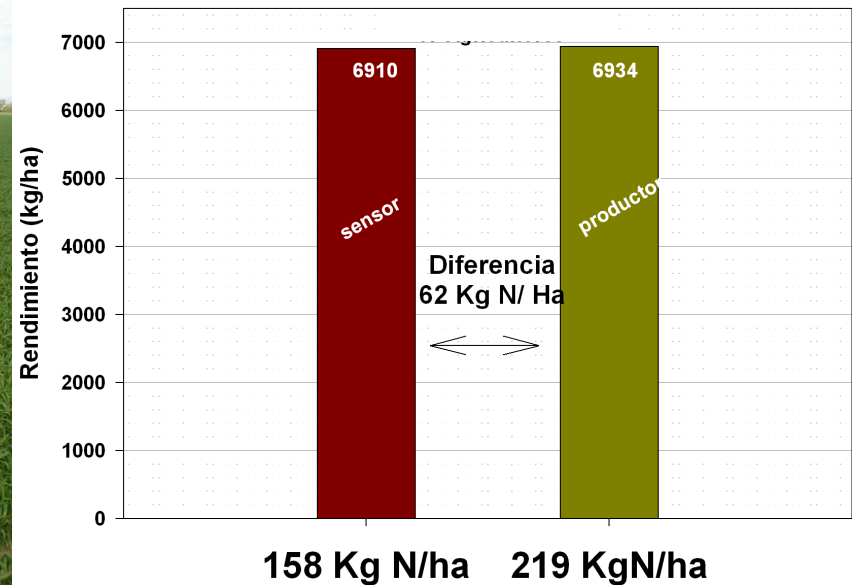
Nitrogen Fertilizer Use by Crop at the Global Level





Wheat

RENDIMIENTO
A.SENSOR vs. A. PRODUCTOR



3 500 has. Valle del Yaqui

Saved 62 kg / ha N at equal yields in 200 farmers fields in Yaqui Valley (6000 kg grain yield)

Breeding for NUE – e.g. through reduced nitrification



Maiz, Sorghum
Sugar Cane



< \$100,00

□ Will run out of P and K before oil ends

Ensuring Production Costs-Savings

Conservation Agriculture Research and Promotion

□ **No till with residue conservation and rotation:**

- Lowering production costs
- Time saving for optimum crop establishment
- Improvement of soil structure



□ **Implemented more readily in intensive/irrigated systems:**

- Several opportunities for rotation
- Adequate residue management not hampered by grazing requirements as in rainfed systems

Extremely Dry Year in El Batan, Mexico



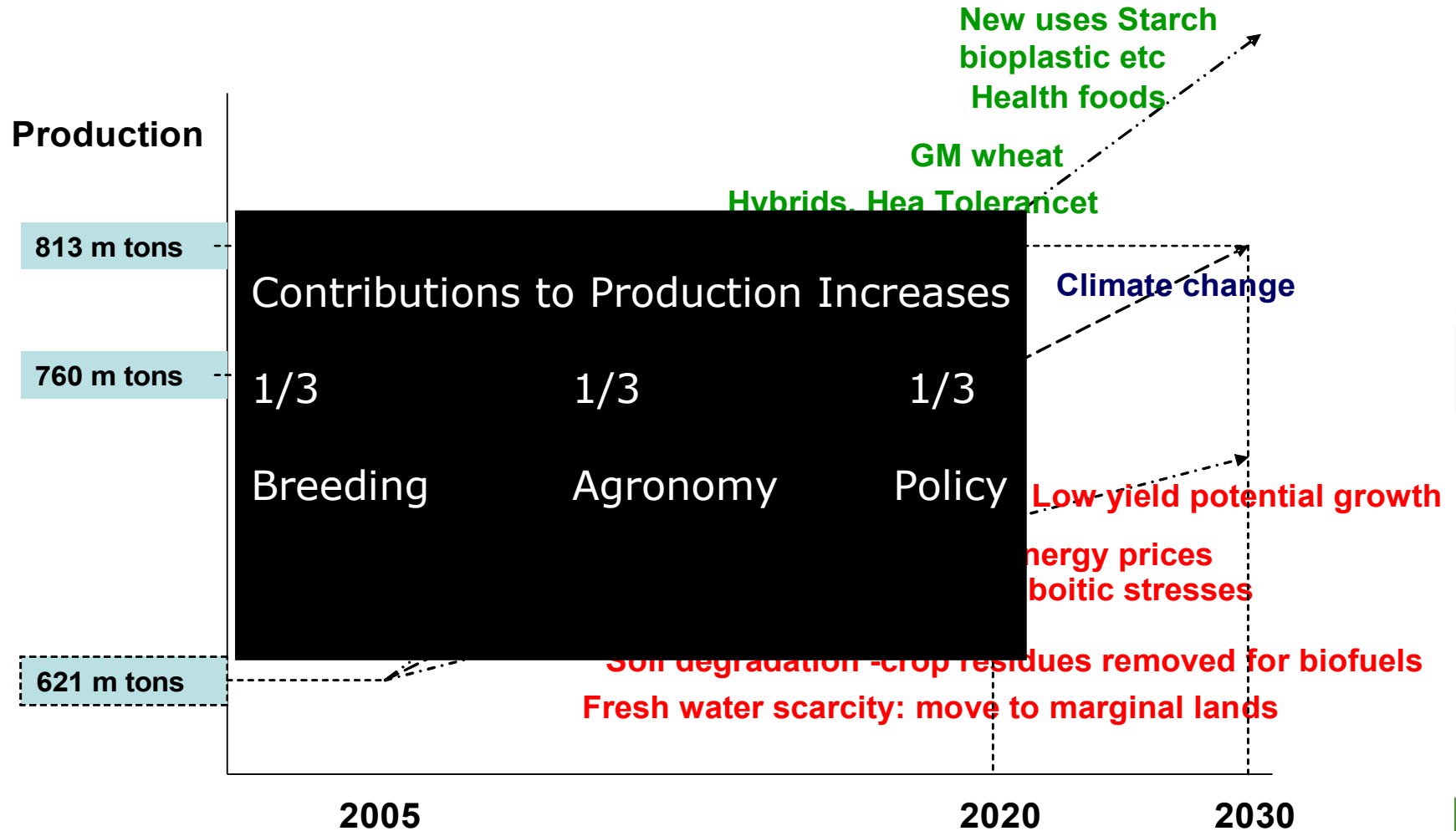
**Conventional tillage
Residues removed**

0-tillage Residues left



Govaerts et al., 2005

Wheat futures



Challenges ahead

- ❑ Decreasing soil fertility limits impact from improved technologies
- ❑ Stagnating yields in many regions and declining response to inputs
- ❑ Water use efficiency and heat
- ❑ Emerging and evolving diseases and pests
- ❑ Linking to end-use quality requirements
- ❑ Competition between food, feed and energy (bio-fuels)

Conclusions

- ❑ Agriculture R&D at a critical stage – food / feed / energy
- ❑ Wheat in LDC mainly consumed as food
- ❑ Wheat stocks at historic low – likely to continue to fluctuate
- ❑ Wheat research in LDC attracts little private sector investments
- ❑ Private sector Investments => IPR / GMO / Hybrid Wheats
- ❑ To meet the 1.5% annual increase, R&D investments in wheat research must increase



Thank You

Norin 10, the donor of the dwarfing gene which saved millions of lives

Chile and Wheat

- ❑ Produces ca 50% of internal consumption – was once self sufficient
- ❑ Environments for Highest Grain Yield
- ❑ Can wheat compete with high value crops?
- ❑ Produces quality the processing industry demands
- ❑ Export high quality(?) wheat and import cheap wheat from Argentina and blend
- ❑ Latin America imports > 10 mln tons (cheap) wheat
- ❑ Niche markets for export – e.g. DON free wheat, oils, cosmetic
- ❑ Producers and processing Industry come to agreement on pricing (price fluctuation)