Society for Advancement of Wheat and Barley Research(SAWBAR)
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Registration No. HR-006-2016-06817

Reflections on Past and Future INDIA-CIMMYT Collaboration on Wheat Improvement

Hans-Joachim Braun

CIMMYT, Global Wheat Program, Mexico

ICAR-IIWBR
September 8, 2020

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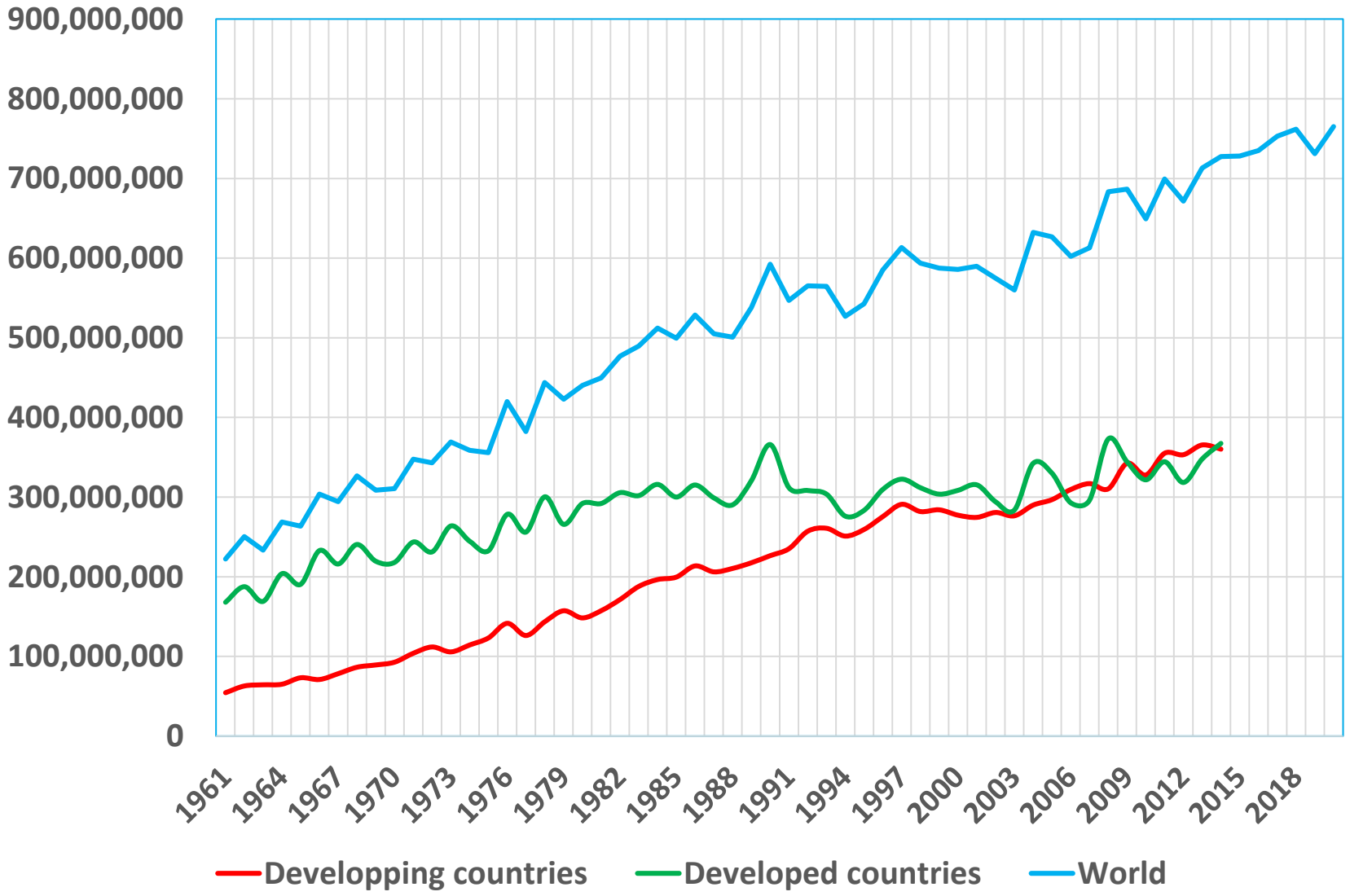
Wheat Production 1961 to 2015: Global, in developing and developed countries (000 tons)



Data Source: FAO, USDA. Compiled by H.-J. Braun

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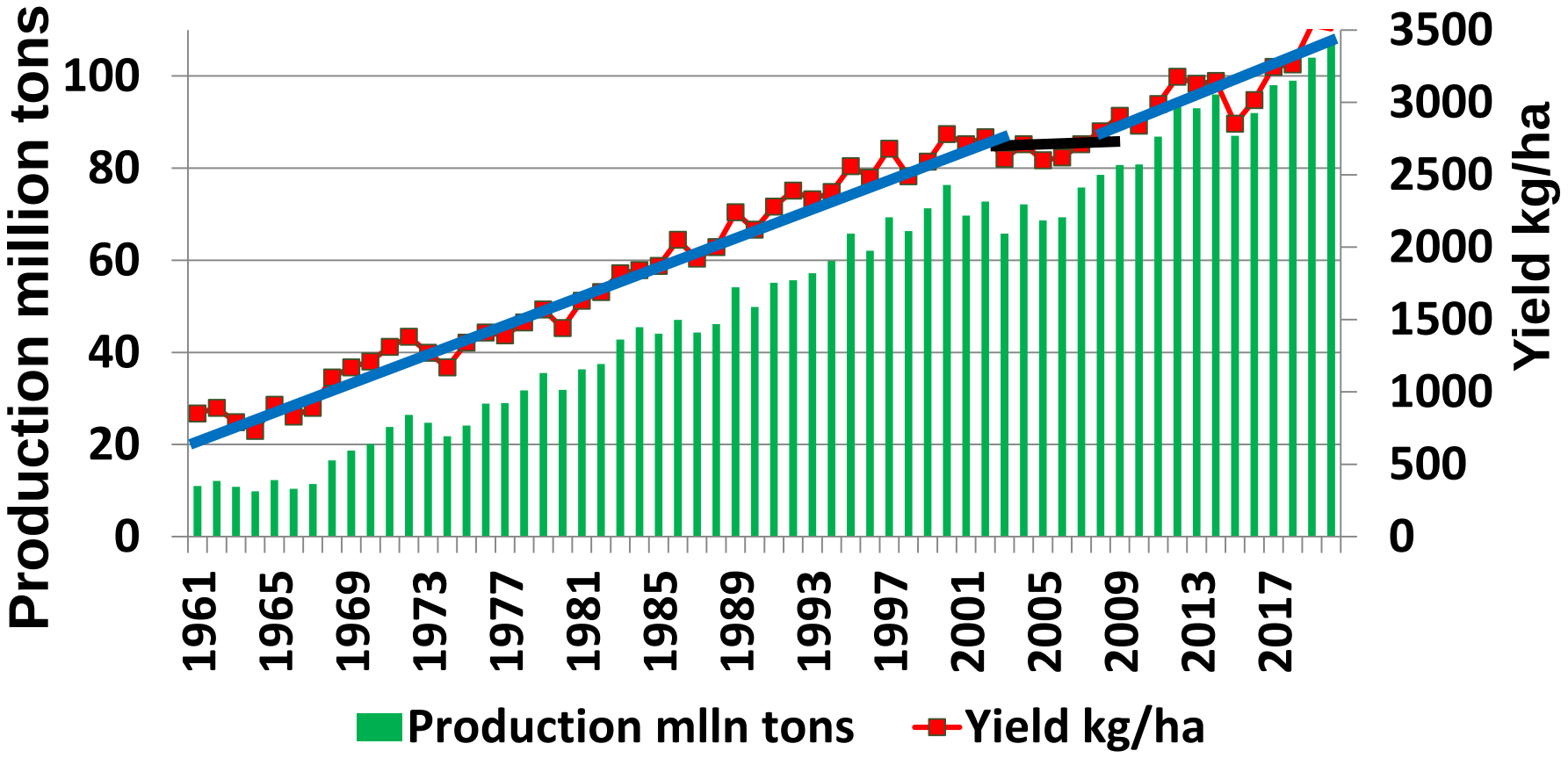
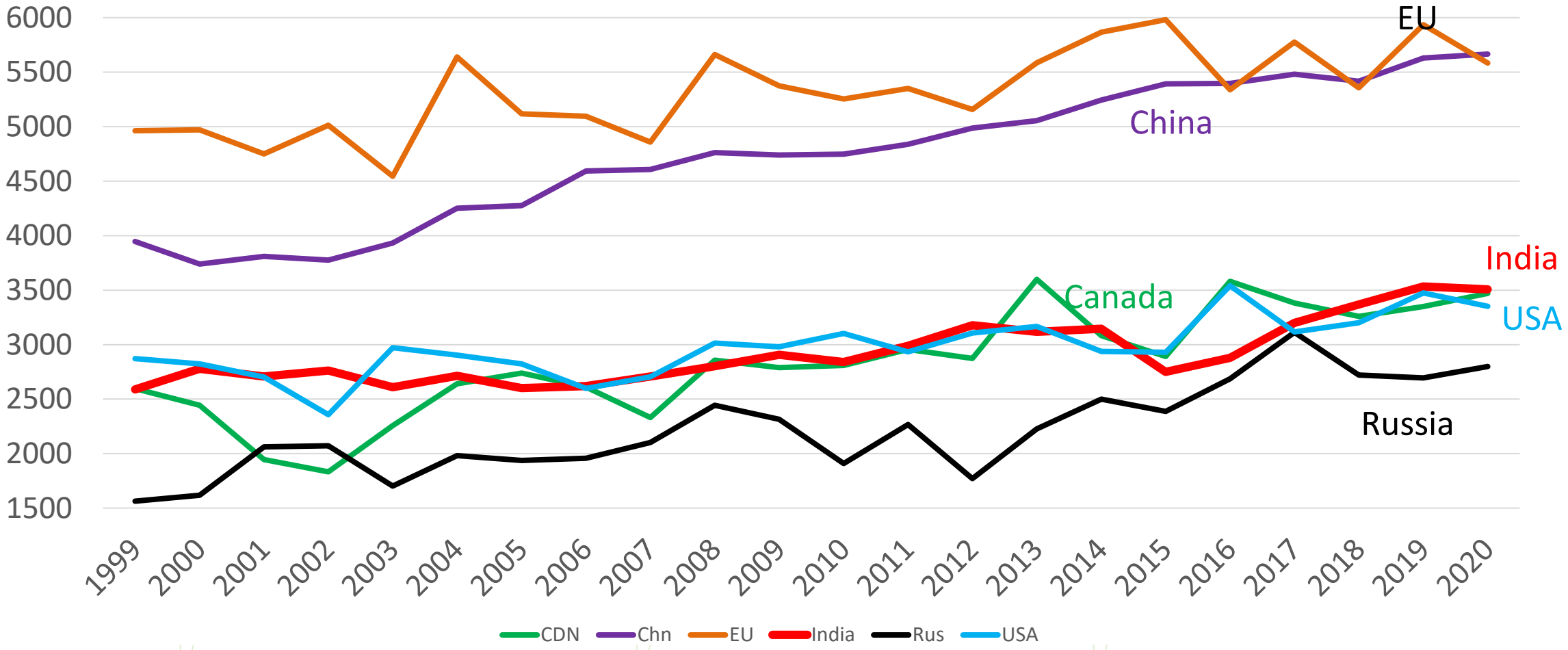
RESEARCH PROGRAM ON
Wheat

India Wheat Yield and Production continues to grow at linear rates



Source: FAO, USDA

Average National Wheat Yield of Major Wheat Producers



Source: Compiled by H.J.Braun Data: USDA

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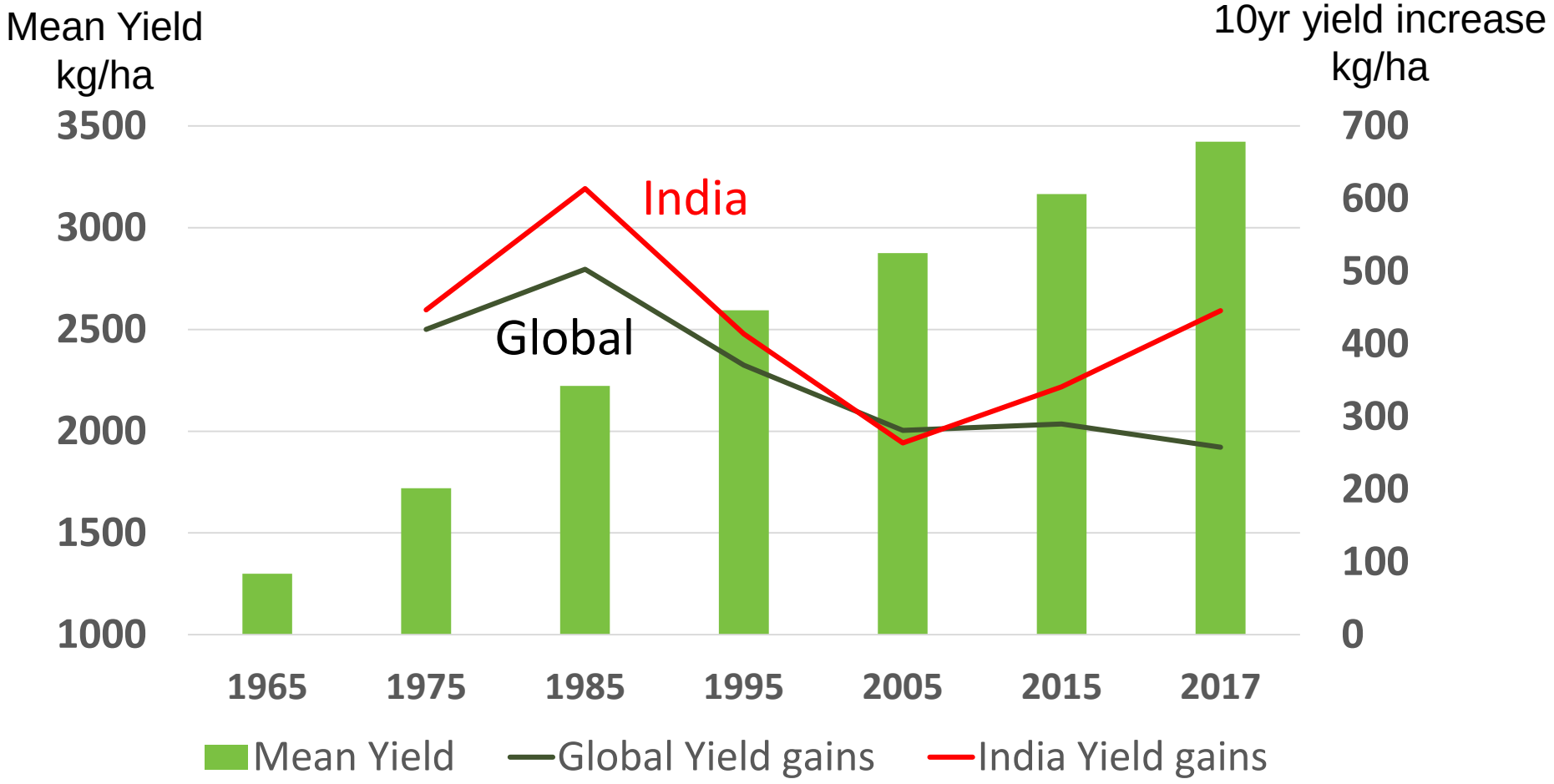
10 year average global wheat yield and average yield increase during a decade



Data: FAO, USDA Compiled by H.-J.Braun

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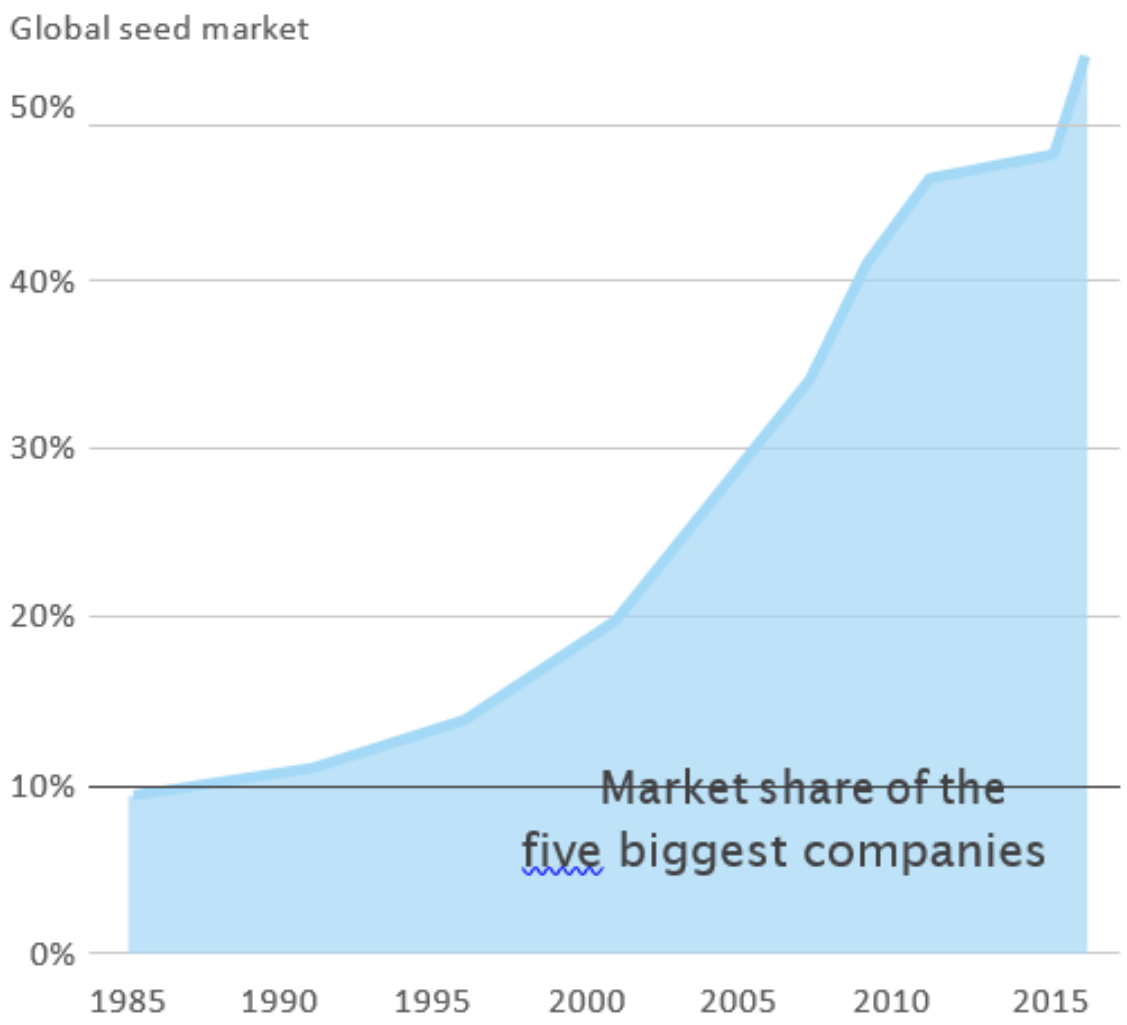
Concentration trends in the seed industry, 1985–2016



Source: Bonny 2017.[142]

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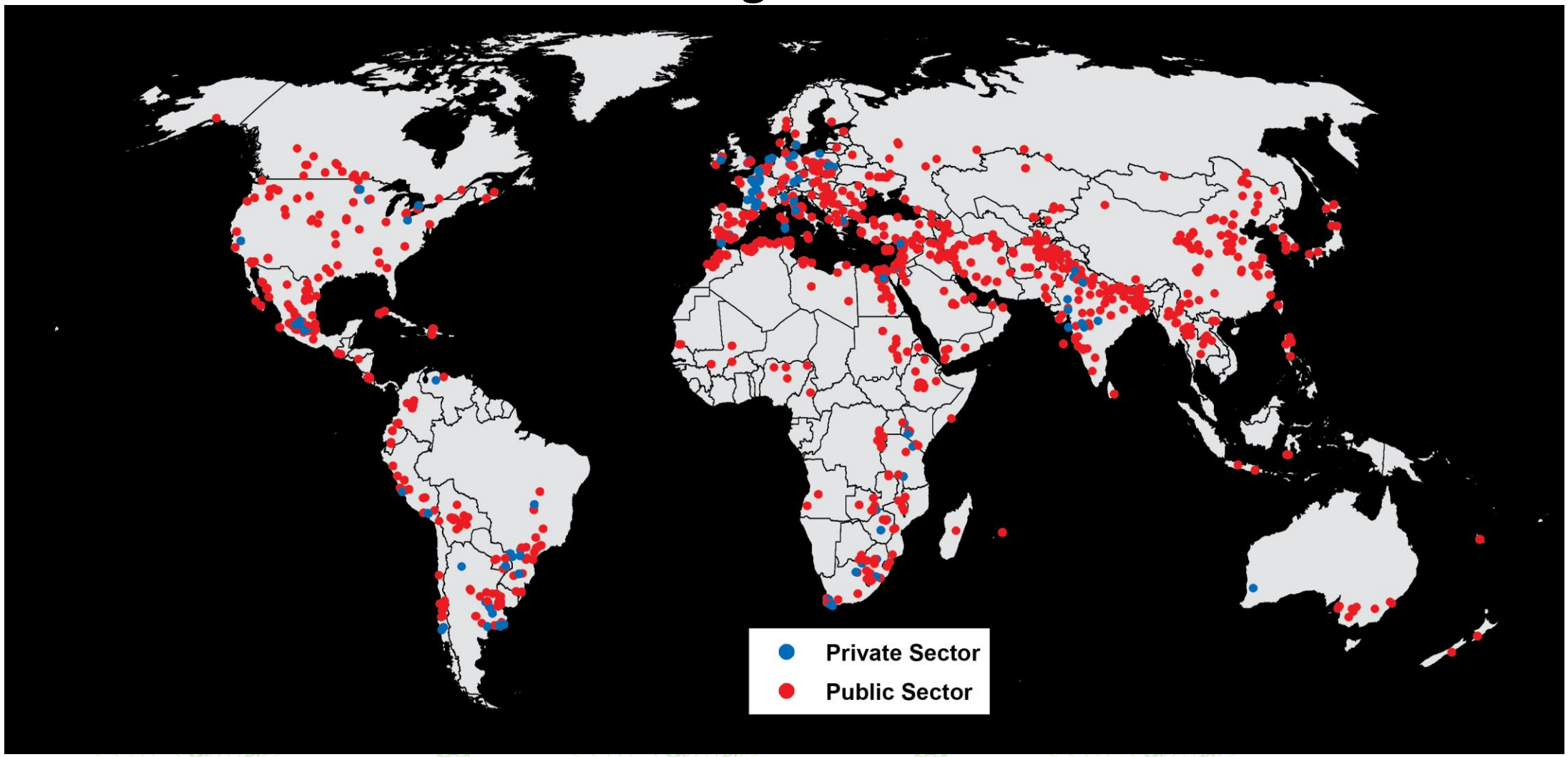
Private and Public Sector Partners in International Wheat Improvement Network (IWIN): Key to Delivering Impacts

Locations receiving CIMMYT nurseries



Source: K. Sonders CIMMYT

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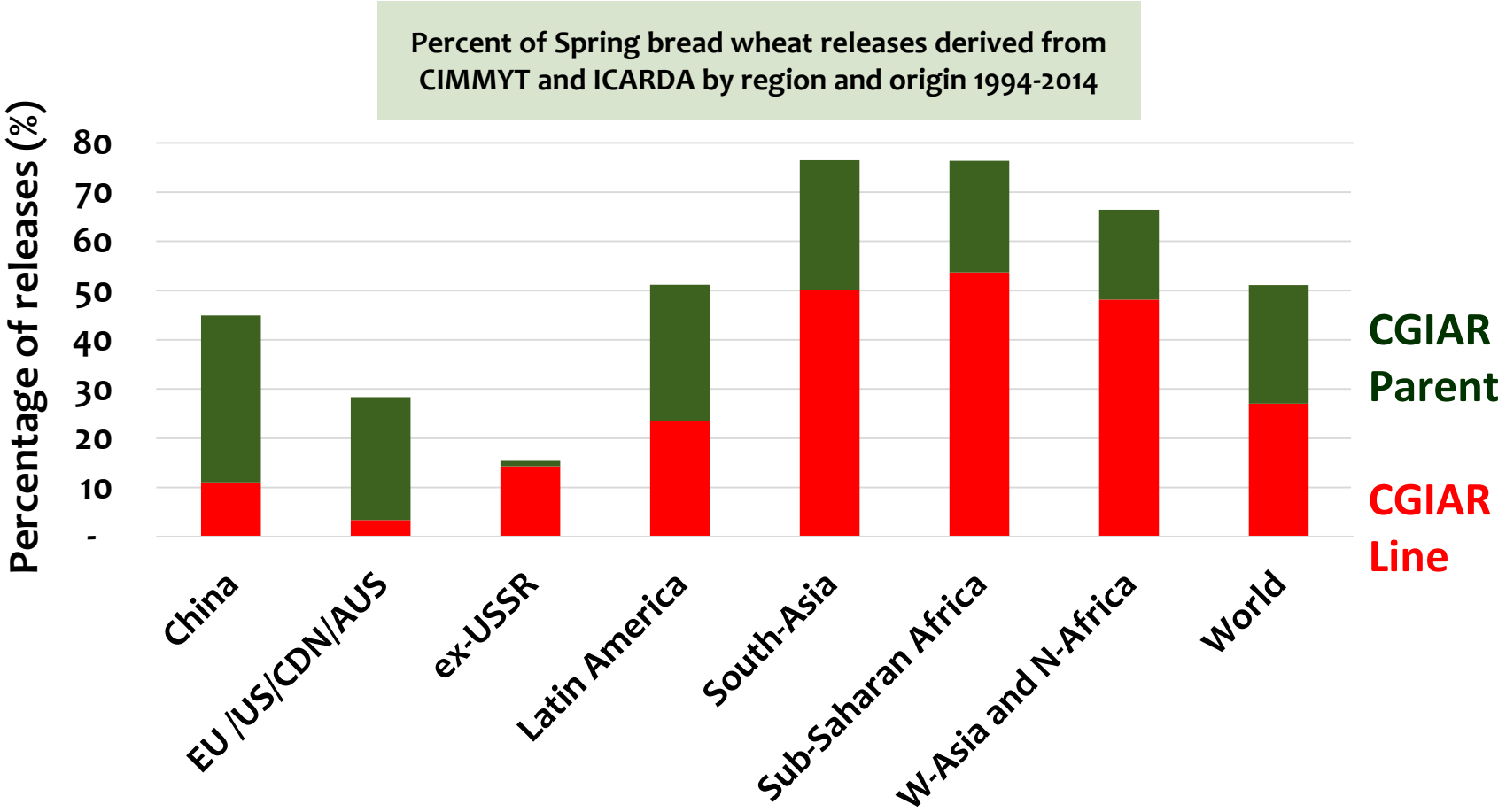
Benefits from IWIN - Key points from survey

- No other crop where one central breeding program has been so dominating
- Model had impact far beyond wheat since it served as model for other crops IRRI first International Center but Wheat first international program
- Has united and standardized the global wheat community to a unique language – we understand each other
- Brings together the global genetic diversity – melting pot for alleles. Increasingly important as free germplasm exchange becomes more and more difficult
- Only publicly available source for improved and genetically diverse germplasm – paramount since IP laws have shut down much of germplasm exchange

Impact of CGIAR Wheat Breeding Germplasm



Note: Percent release roughly represents area sown to CIMMYT derived wheat varieties

Lantican M.A., H.J. Braun, T.S. Payne, R.P. Singh, K. Sonder, M. Baum, M. van Ginkel and O. Erenstein. 2016. Impacts of International Wheat Improvement Research, 1994-2014. Mexico, D.F.: CIMMYT.

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Our germplasm goes to about 50 locations

INDAIN Centers

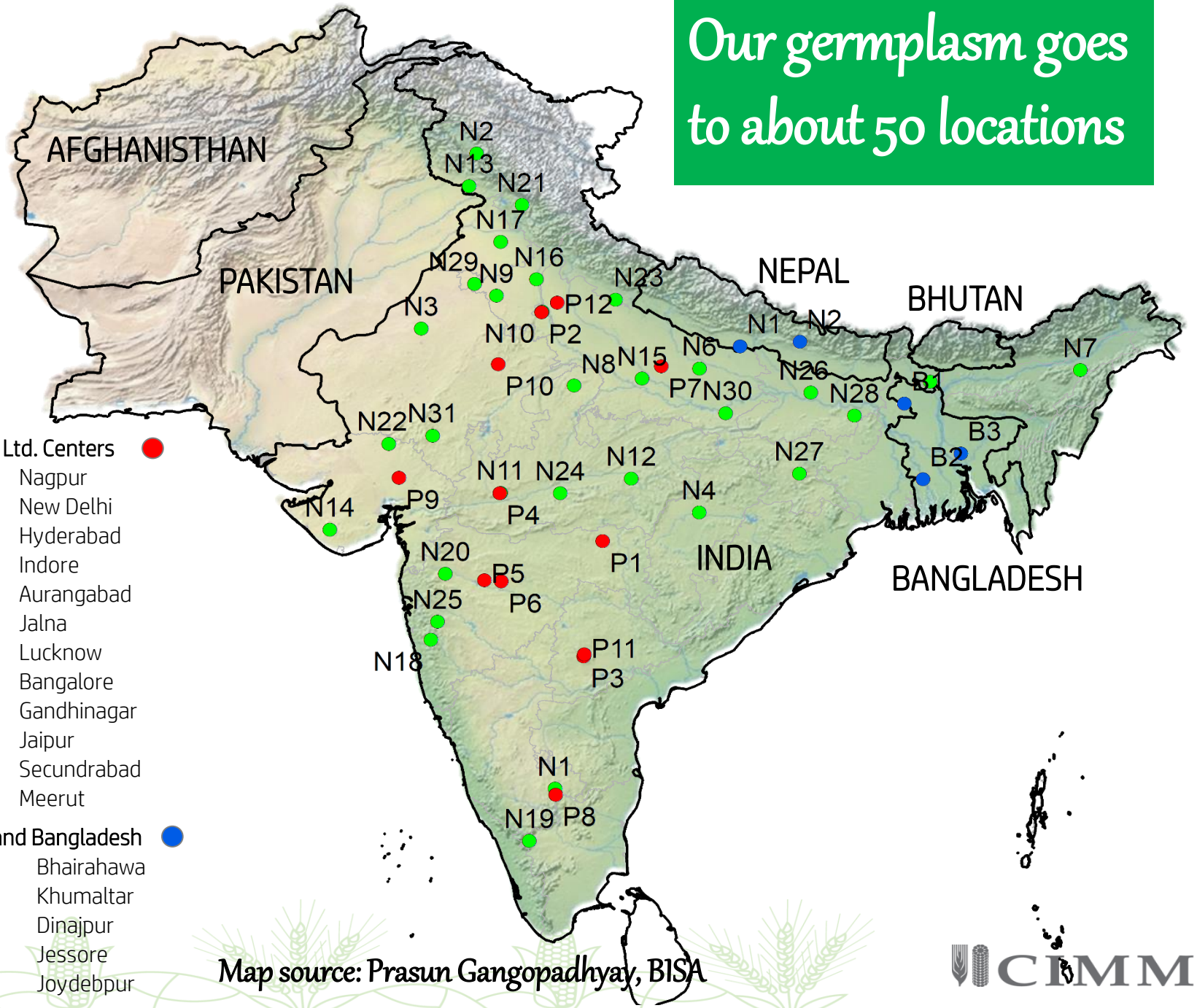
N1	Bangalore
N2	Bijbehara
N3	Bikaner
N4	Bilaspur
N5	Coochbehar
N6	Faizabad
N7	Guwahati
N8	Gwalior
N9	Hisar
N10	New Delhi
N11	Indore
N12	Jabalpur
N13	Jammu
N14	Junagarh
N15	Kanpur
N16	Karnal
N17	Ludhiana
N18	Mahabaleshwar
N19	Nilgiris Hills
N20	Niphad
N21	Palampur
N22	Palanpur
N23	Pantnagar
N24	Powarkheda
N25	Pune
N26	Pusa
N27	Ranchi
N28	Sabour
N29	Sirsa
N30	Varanasi
N31	Udaipur

Private Ltd. Centers

P1	Nagpur
P2	New Delhi
P3	Hyderabad
P4	Indore
P5	Aurangabad
P6	Jalna
P7	Lucknow
P8	Bangalore
P9	Gandhinagar
P10	Jaipur
P11	Secundrabad
P12	Meerut

Nepal and Bangladesh

N1	Bhairahawa
N2	Khumaltar
B1	Dinajpur
B2	Jessore
B3	Joydebpur



Map source: Prasun Gangopadhyay, BISA

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CIMMYT International Wheat Improvement Network Partners
(Nurseries distributed 2001-2013)

Other Partners: Albania, Angola, Austria, Belarus, Belgium, Belize, Bhutan, Botswana, Burkina Faso, Cameroun, Colombia, Croatia, Cuba, Cyprus, Czech Republic, Denmark, Eritrea, Estonia, Fiji, Gambia, Guatemala, Guyana, Honduras, Indonesia, Ireland, Jamaica, Japan, Jordan, Kyrgyzstan, Lebanon, Lesotho, Lithuania, Macedonia, Malawi, Mali, Mauritius, Moldova, Mongolia, Netherlands, New Caledonia, New Zealand, Nicaragua, Qatar, Rep. Congo, Senegal, Somalia, Sri Lanka, Swaziland, Taiwan, Turkmenistan, Uganda, United Arab Emirates, Venezuela, Viet Nam

The size of the font indicates the relative size of the distribution

Source: T. Payne, CIMMYT

CIMMYT International Maize and Wheat Improvement Center

CIMMYT

The Borlaug Institute for South Asia

"If you desire peace, cultivate justice, but at the same time cultivate the fields to produce more bread; otherwise there will be no peace."

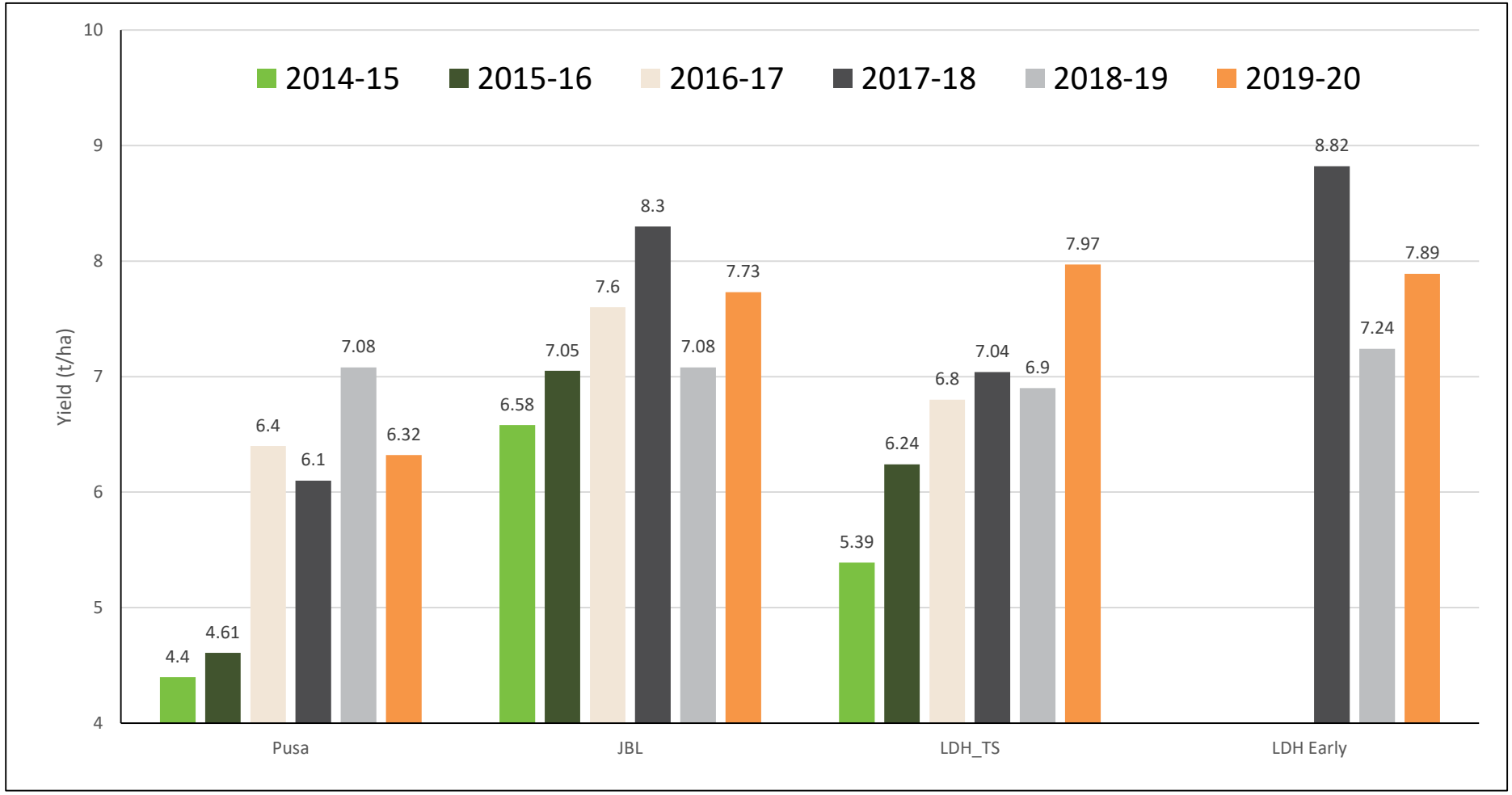
"The first essential component of social justice is adequate food for all mankind. Food is the moral right of all who are born into this world."

Dr. Norman E. Borlaug

(1914-2009)

[MYT MR

Yield at three BISA stations during last 6 years



Results are based replicated yield trials of 600 genotypes
One possible region of nearly linear increase is testing of more lines per year in Mexico

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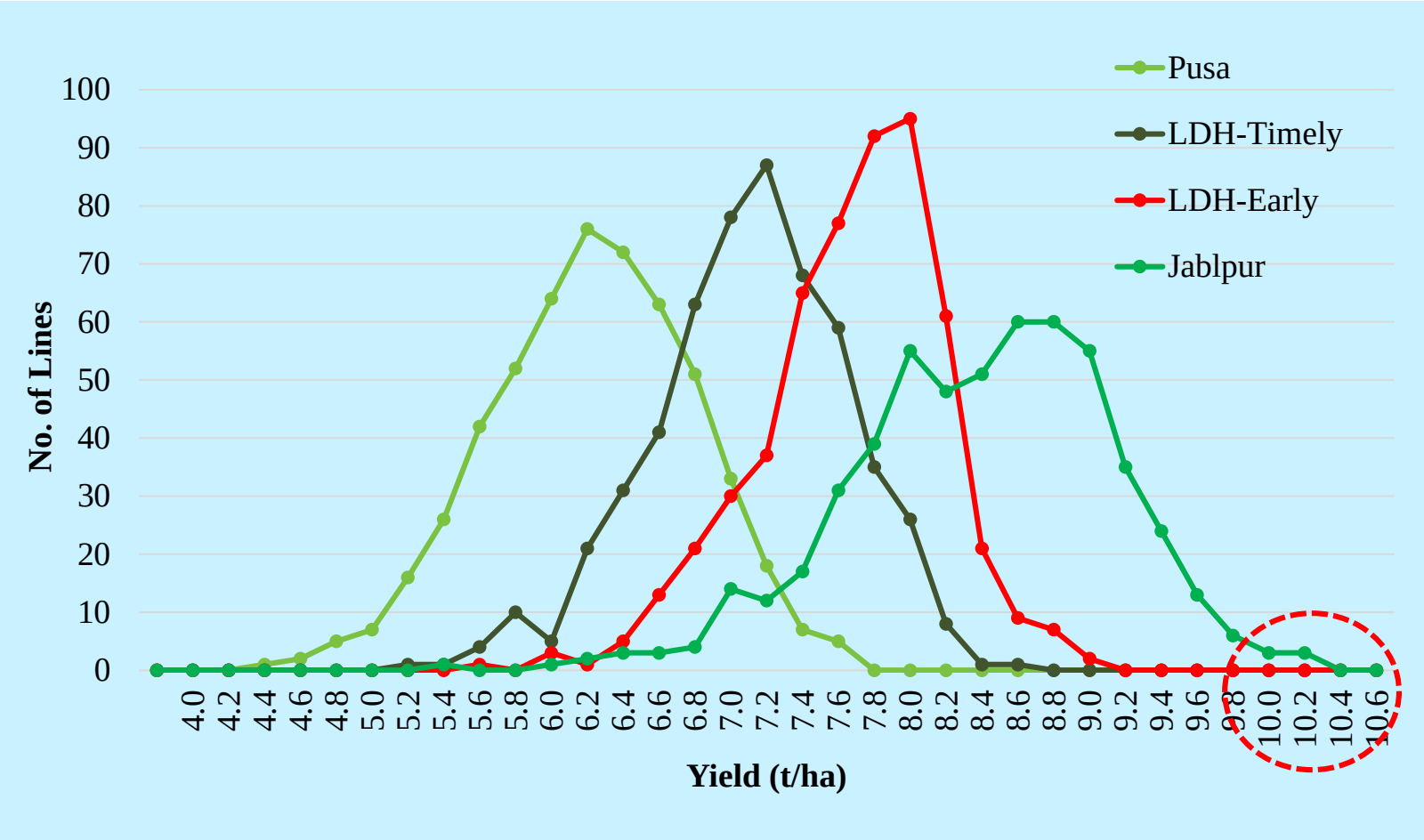
1. For the first time in South Asia, 10 t/ha grain yield achieved (location: BISA, India)
2. To see the potential of CIMMYT lines, DG ICAR desired first coordinated high yield trial for fast track varietal release which is in place now



Additional: 1st biofortified wheat released in India

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EAT–Lancet Commission report on healthy diets from sustainable food systems

- Food production today already unsustainable
- Cereals will remain important in future diets (1/3 calories & protein contribution)
- Investments to increase cereal systems productivity / efficiency paramount

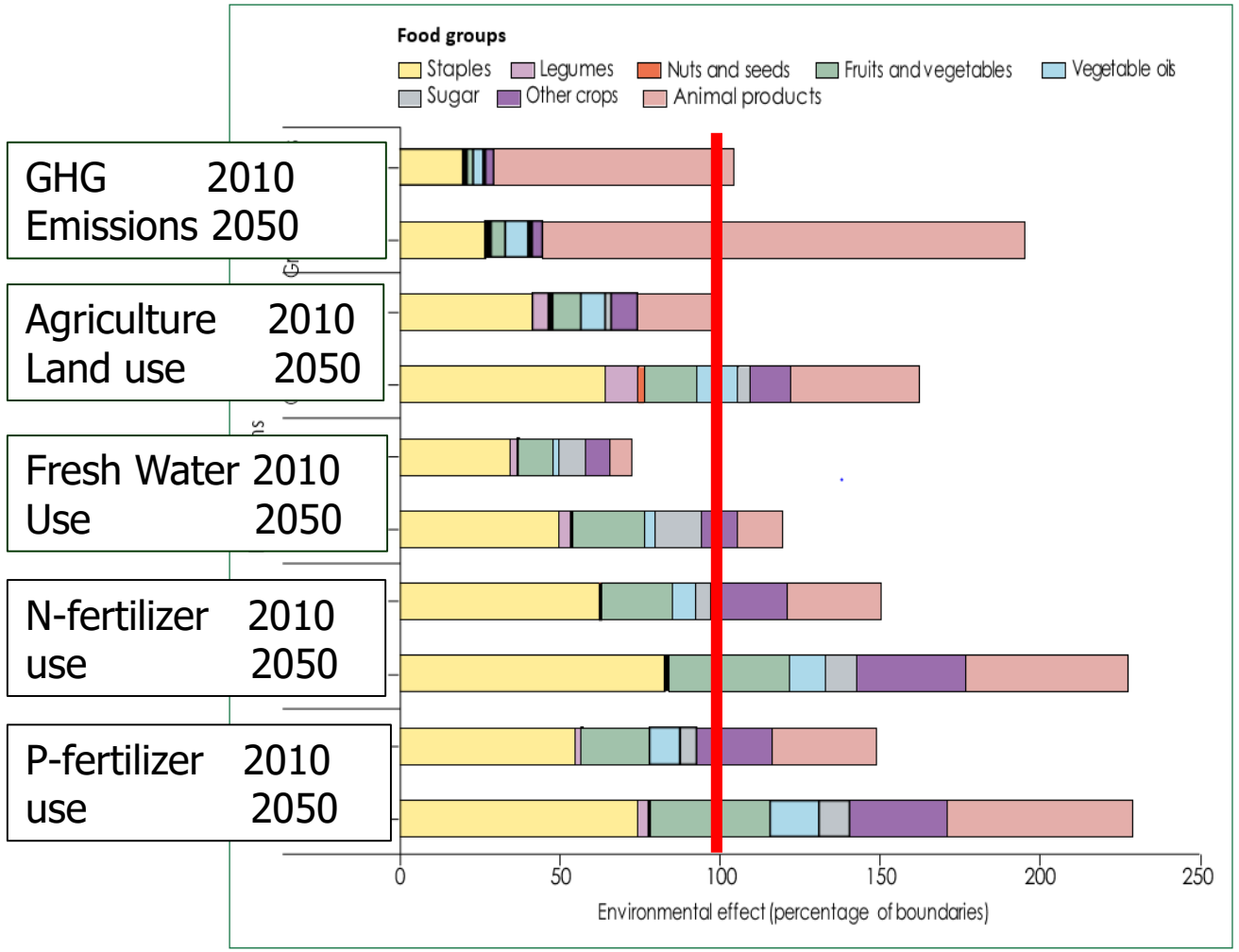

Figure 5: Environmental effects in 2010 and 2050 by food groups on various Earth systems based on business-as-usual projections for consumption and production

EIAR Ethiopian Institute of Agricultural Research

Cornell University

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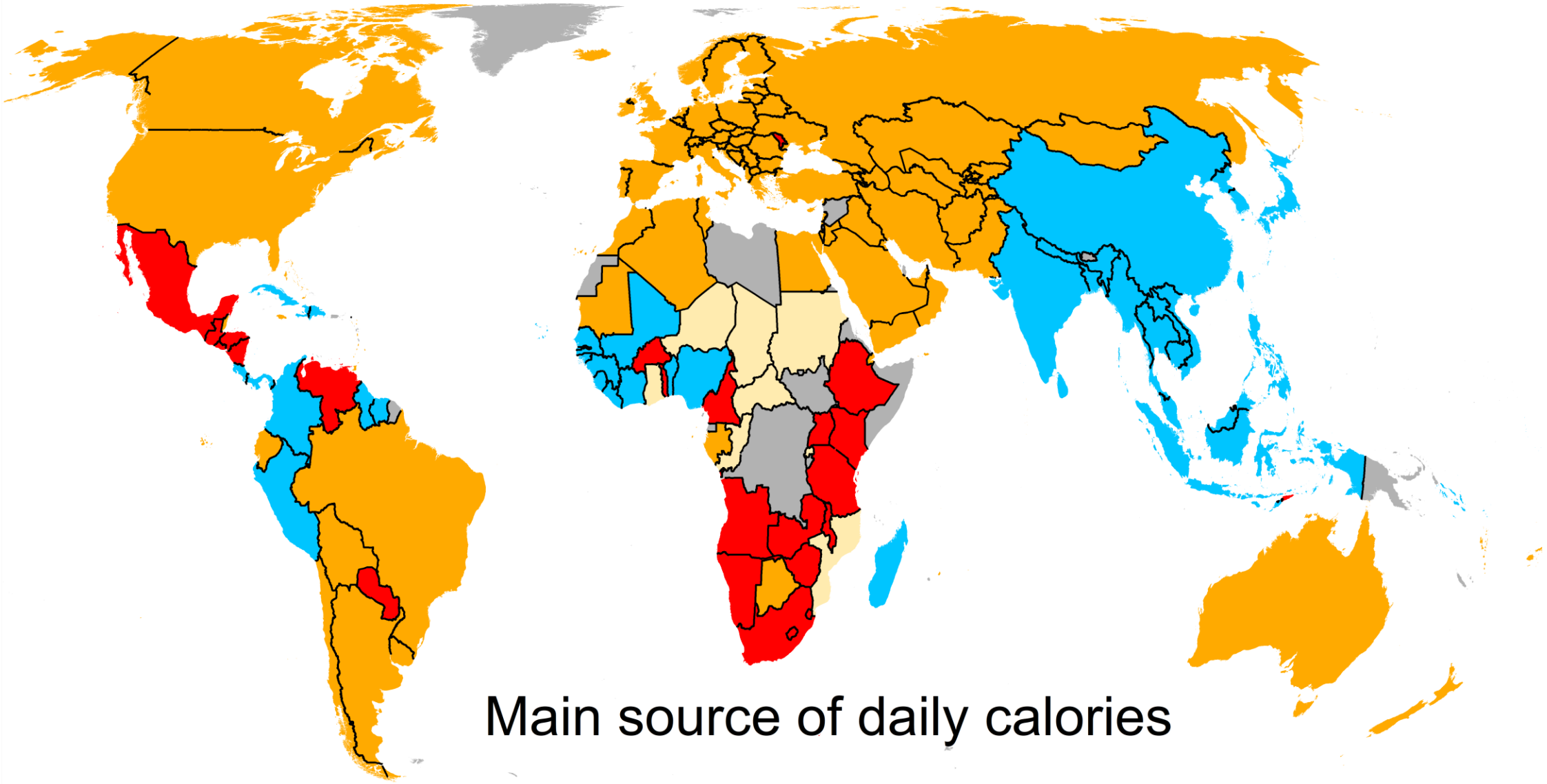


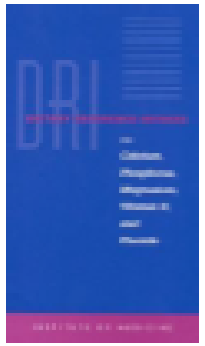
Main source of daily calories

Rice **Wheat** **Maize** **Other Crop** **No Data**

Data sources:
FAOSTAT (Average 2015 2017)
FAO GAUL

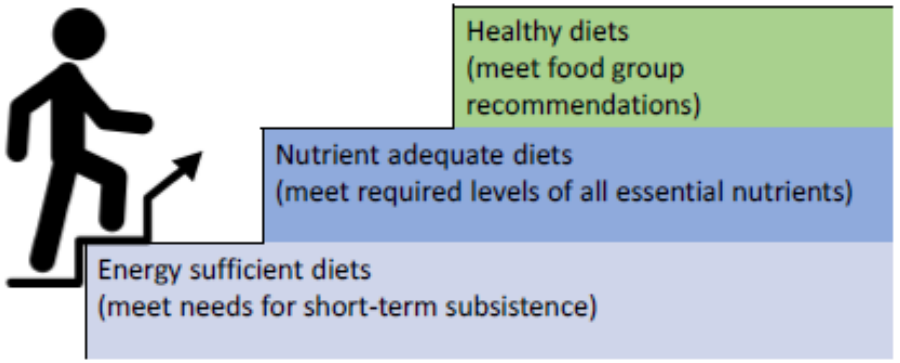
We estimate the cost of three diets

- Cost of Calorie Adequacy (CoCA)
  - minimum cost to meet energy requirements using the least cost available starchy staple food in each country



- Cost of Nutrient Adequacy (CoNA)
  - minimum cost to meet energy and nutrient requirements (23 macro and micro-nutrients, with upper as well as lower bounds)

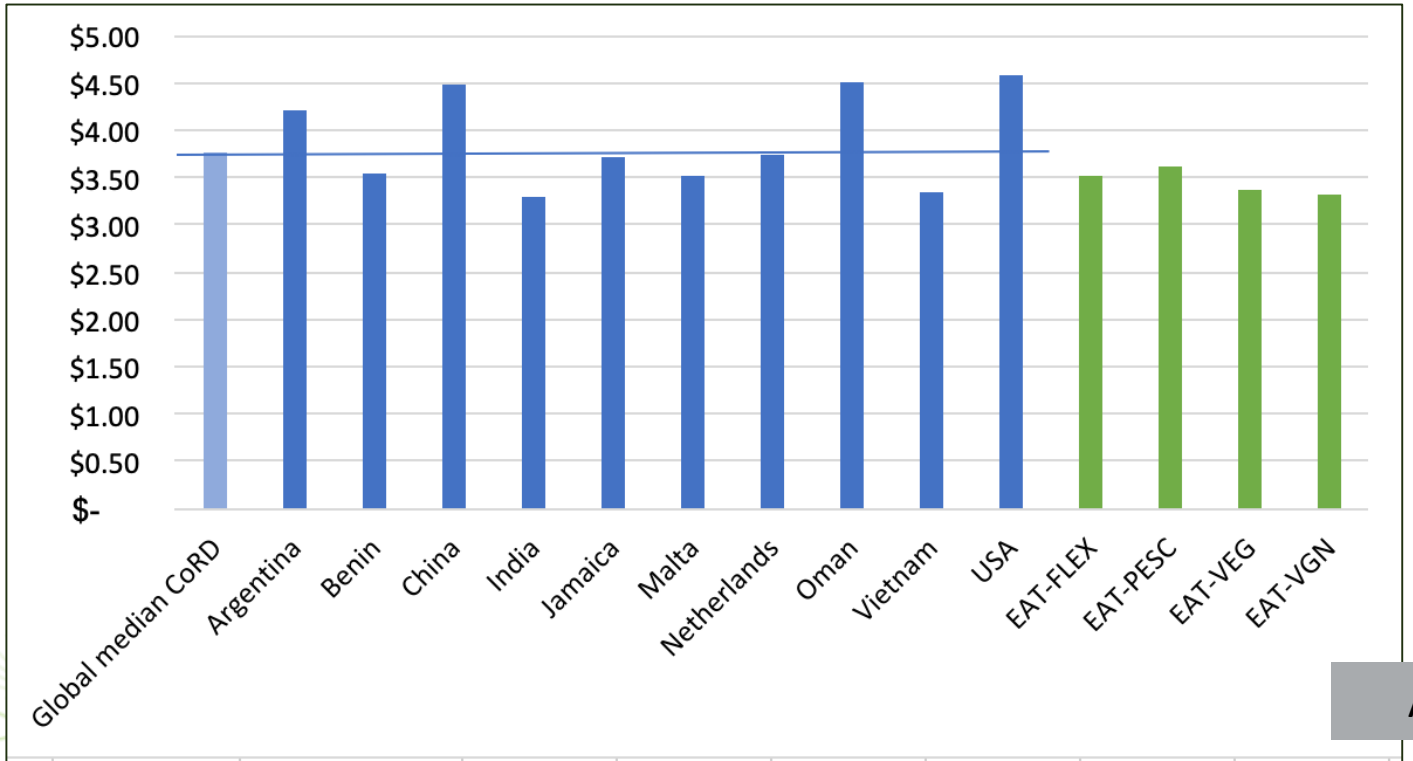
- Cost of Recommended Diet (CoRD)
  - Minimum cost to meet food-based dietary guidelines, based on food group classifications



Anna Herforth et al., 2020

Main results: Global average costs

- **$0.79** per day to meet daily energy needs using the most affordable starchy staple
- **$2.34** per day to meet all essential nutrient requirements
  - *no requirement for proportionality/palatability*
- **$3.75** per day (range **$3.29 to $4.58**) to meet dietary recommendations
  - *we use 10 different definitions of a healthy diet published by UN member states (no single definition of a healthy diet)*



Anna Herforth et al., 2020

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The future of Wheat – Wheat Berries

908 g Hard Red Spring = Wheat Berries

103 MPesos = 5.5. US$ / kg

6046 US$ / ton of wheat

Farm Wheat Price: 202 $/ ton

30 x what a farmer gets

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A healthy diet is unaffordable for the poor in every region of the world

a) Cost of an energy sufficient diet compared with the international poverty line

b) Cost of a healthy diet compared with the internation poverty line

No data | <1.33$ | 1.33-1.9 | >1.9$

NOTES: Maps show the affordability of each of the three reference diets (energy sufficient, nutrient adequate and healthy diet) by comparing the cost of each of them with the international poverty line (USD 1.90 PPP a day) in 159 countries in year 2011, converted to l

Peer-reviewed research shows that micronutrient deficiency is "likely to remain problematic under all modelled scenarios" through 2050…

*Source: World Bank, Nutrition at a Glance country briefs
** Source: Nelson et al., Nature Sustainability (2018)

Zinc enriched wheat varieties in South Asia

Pakistan: Zincol 2016;
Pipeline variety: NR443

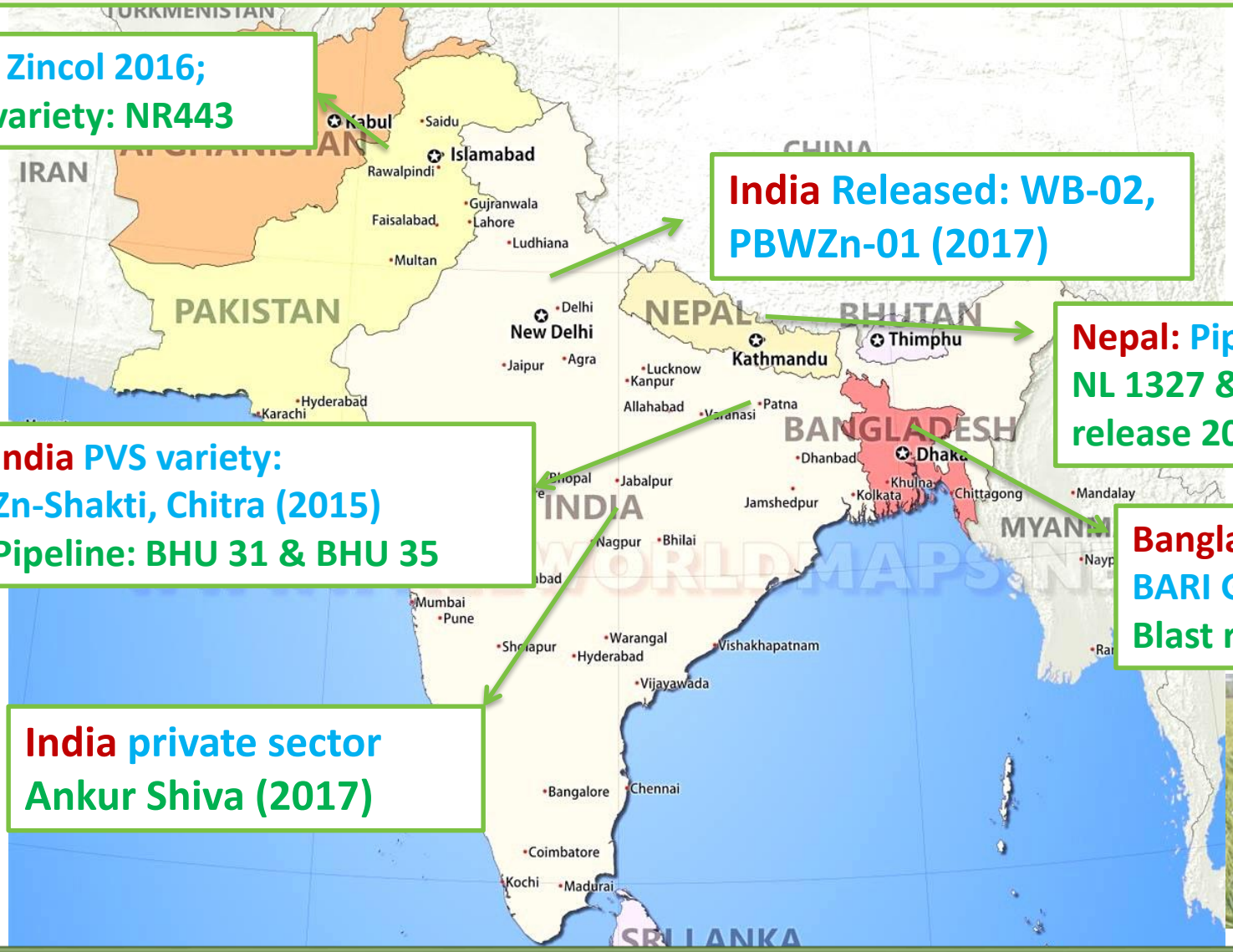
India Released: WB-02, PBWZn-01 (2017)

Nepal: Pipeline variety NL 1327 & 1328 (expected release 2019-20)

India PVS variety:
Zn-Shakti, Chitra (2015)
Pipeline: BHU 31 & BHU 35

Bangladesh
BARI Gom 33 (2017)
Blast resistant

India private sector
Ankur Shiva (2017)



From genetic resources to High zinc wheat in farmers' fields of South Asia in less than 10 years with 20-40% more zinc

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Effect of High Zinc Wheat Intervention on Morbidity Indicators

Indicator	High Zinc Wheat Subjects	Low Zinc Wheat Subjects	Days of Sickness Averted For ~ 1300 Subjects Over 180 Days	Difference Significant at 5% Level of Confidence?
Children 4-6 Years				
Days With Pneumonia	203	244	41	YES
Days With Vomiting	60	99	39	YES
Women 15-49 Years				
Days With Fever	999	1092	93	YES

Sazawal et al. 2018

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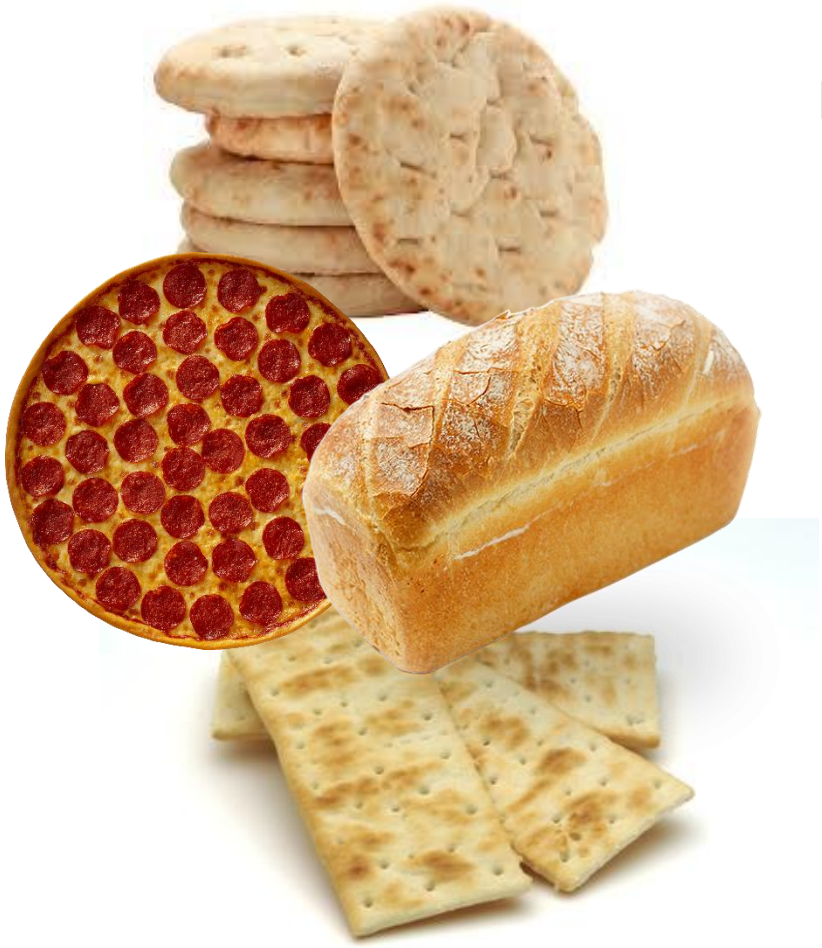
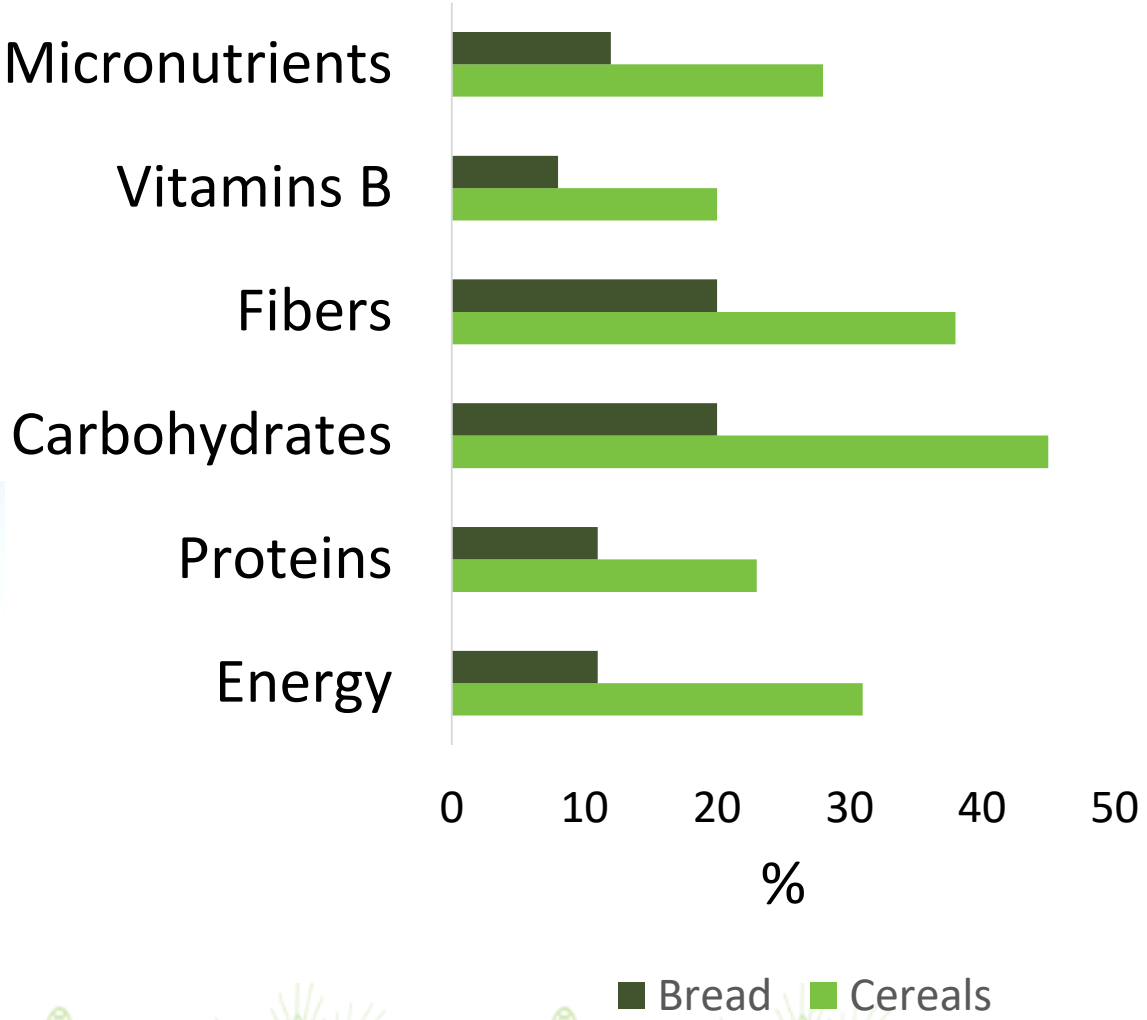
Wheat contribution to daily intake





Source: The UK National Diet and Nutrition Survey 2014

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Crop/Scenario	Asia
Cereal Grains	
Barley	9
Maize	3
Millet	4
Rice	2
Sorghum	6
Wheat	1
Roots, Tubers & Bananas	
Banana	16
Cassava	12
Plantain	19
Potato	5
Sweet potato	11
Yam	15
Oilseeds & Pulses	
Beans	14
Chickpea	20
Cowpea	17
Groundnuts	7
Lentils	18
Other pulses	13
Pigeonpea	8
Soybean	10

NIPI

The Nutrient Investment Productivity Index (NIPI) ranks crop-specific productivity growth for its contributions across multiple deficit nutrients.

NIPI sums the rank order values for each nutrient and then rank orders the results. The result is an index from 1 - most number of deficient adequacy ratios improved)

Source: Wiebe et al., 2018: Modeling Impacts of Faster Productivity Growth: Inputs to the Multi-Donor Initiative on Crops to End Hunger IFPRI/USDA/ Commissioned paper by USAID.

Data Source: FAO / USDA
Slide Source: W.H. Pfeiffer, H+

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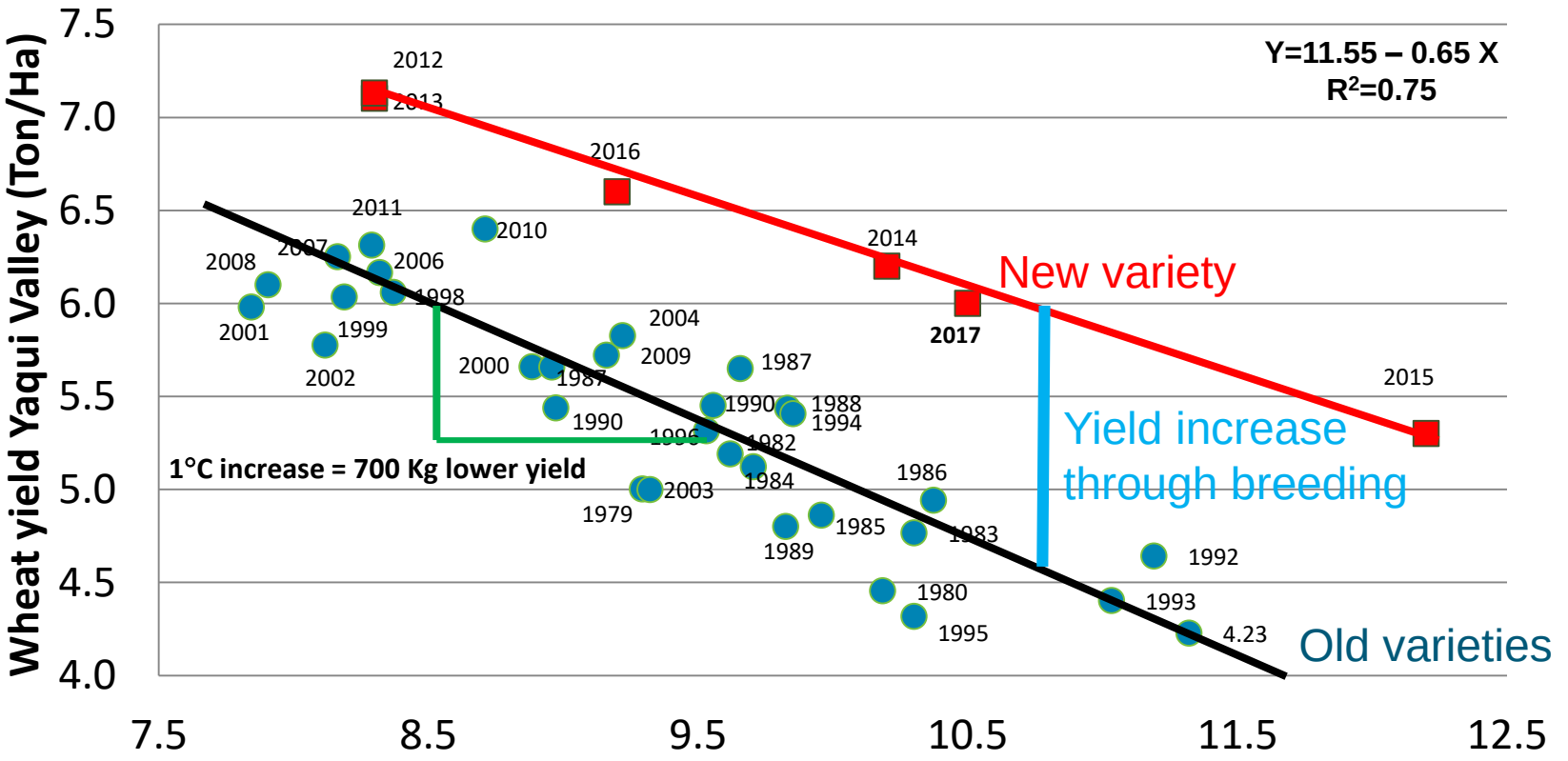
Wheat and heat and irrigation

Adapting to Climate Change: Heat Tolerant Wheats prove their Value in Farmers' Fields in Mexico



4.4 C° variation from 1981 to 2017

January-April Average min. Temperature C°

Source: H.-J. Braun and I. Ortiz-Monasterio, CIMMYT

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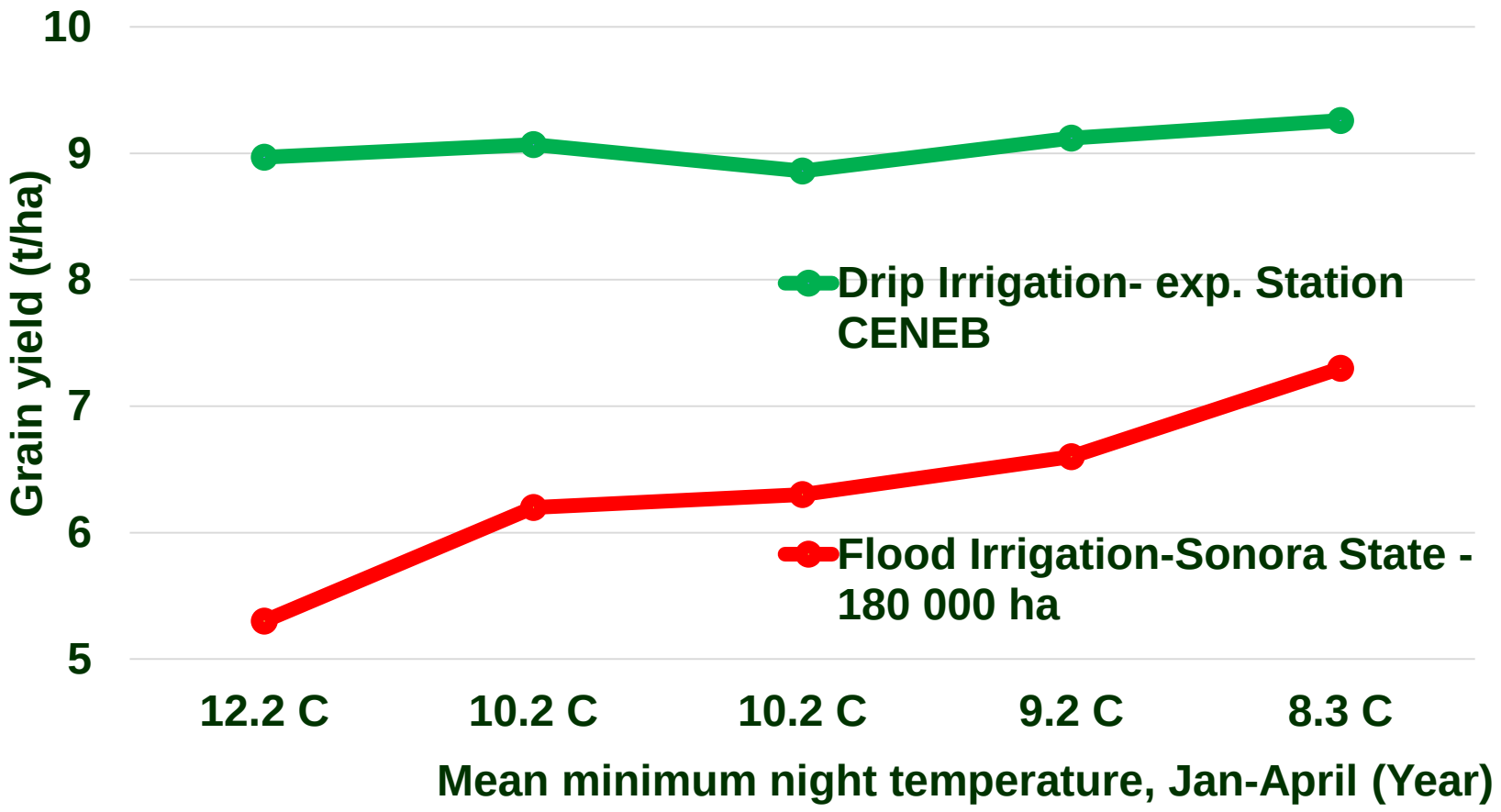
WUE! in GxExM context

Yield of CIRNO2008 in Yaqui Valley farmers fields (bed irrigation) and surface drip irrigation on CENEB during 2013 - 2017



Data: S. Mondal et al., paper submitted

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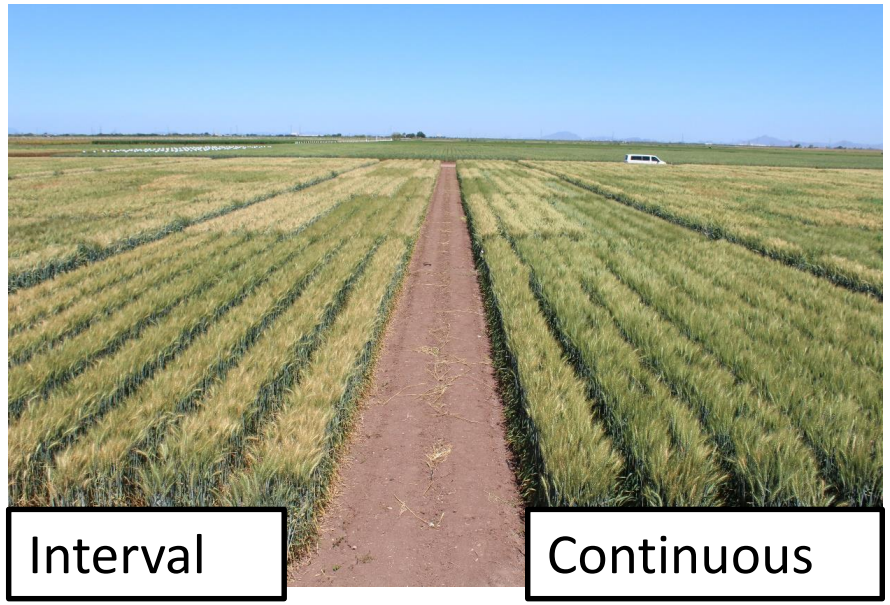
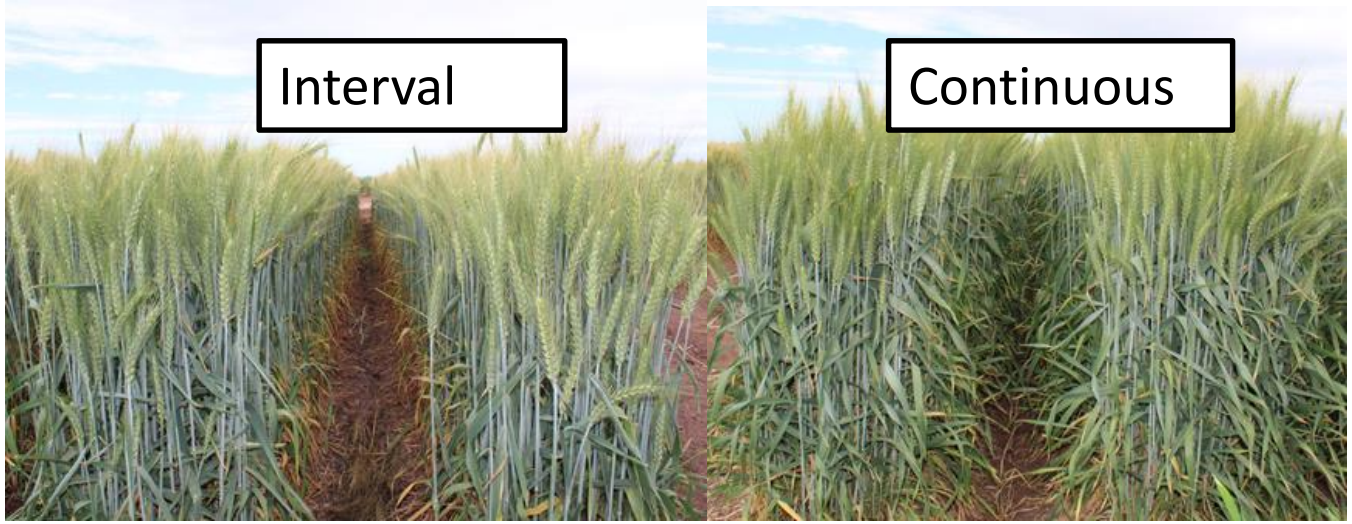
Continous drip irrigation Side study on Irrigation

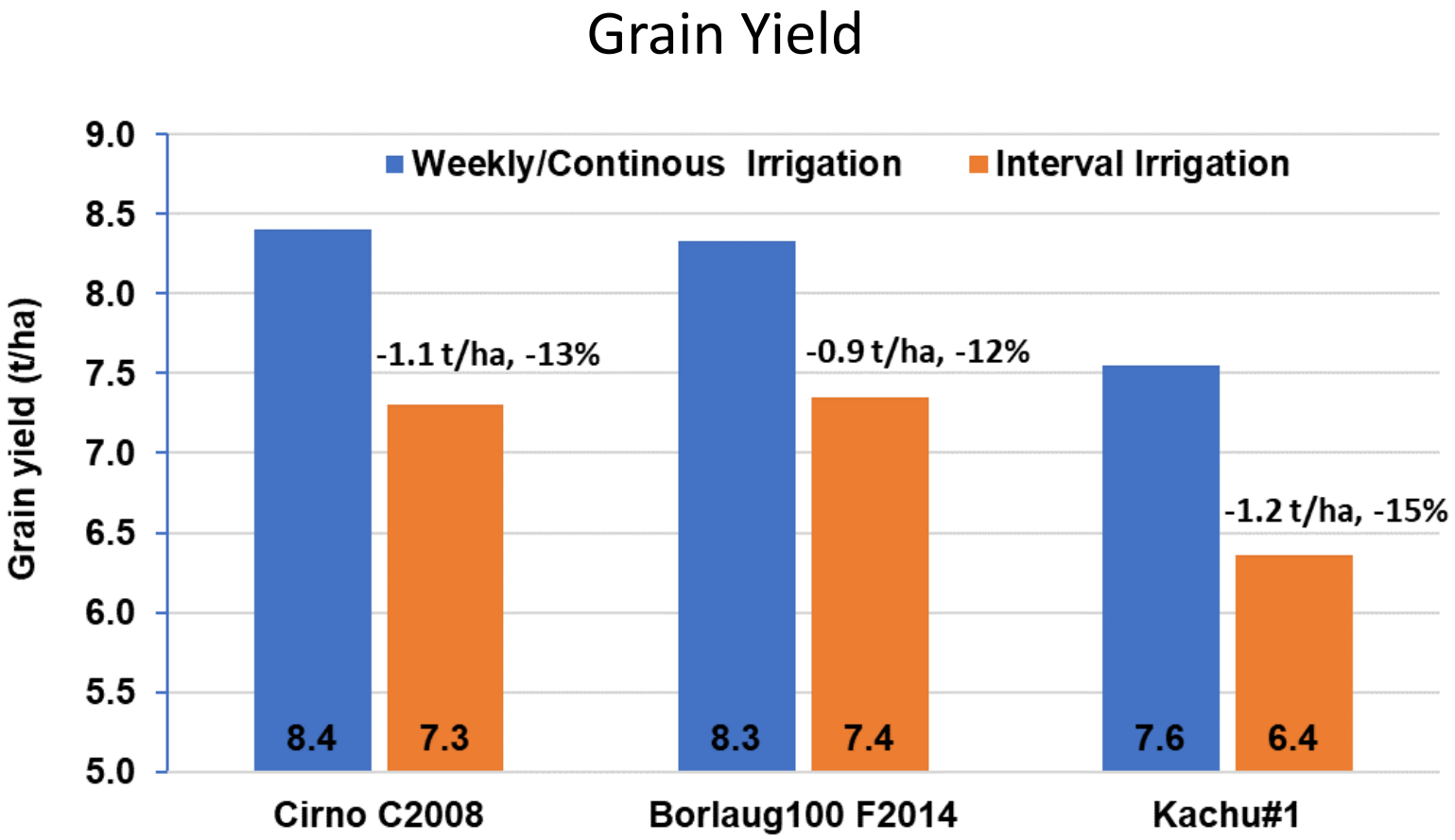




- Same seed rate, irrigation water and fertilizer given two sets of experiments
- Difference: one receives water every 7 days (continuous) the other every 25-27 days (interval)

Visible differences observed, High biomass and tillering

Trait differences



- No difference in Thousand grain weight

- Differences in other traits under continuous (CI) vs interval irrigation
  - Heading : 3 -4 days longer in CI
  - Maturity: 7 days in BW and 10 days in DW longer in CI
  - Biomass: 10% higher in CI, 1t/ha difference
  - Grain number & tiller number: 8-10 % higher in CI

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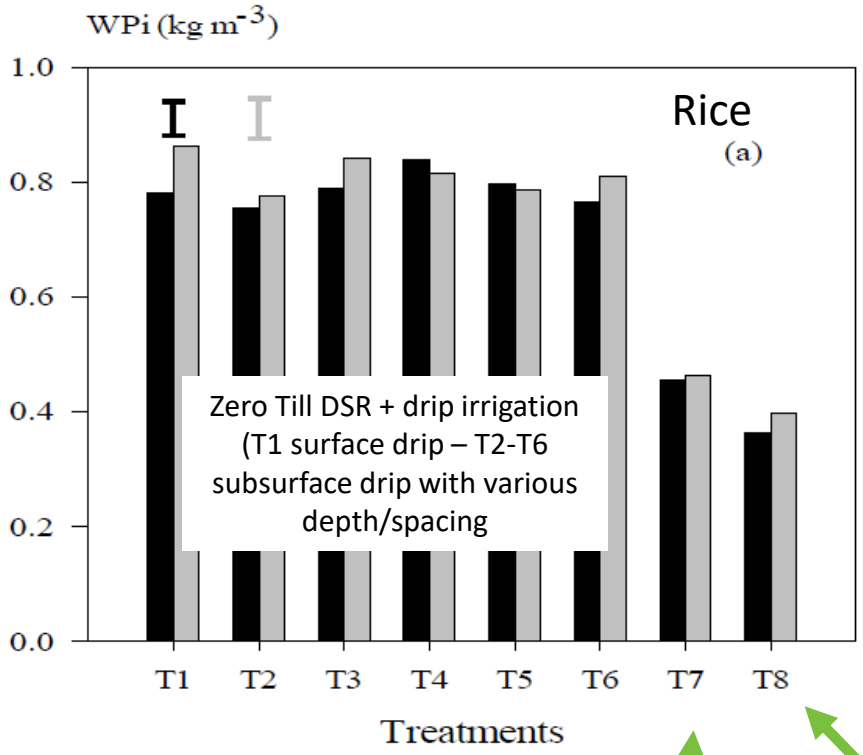
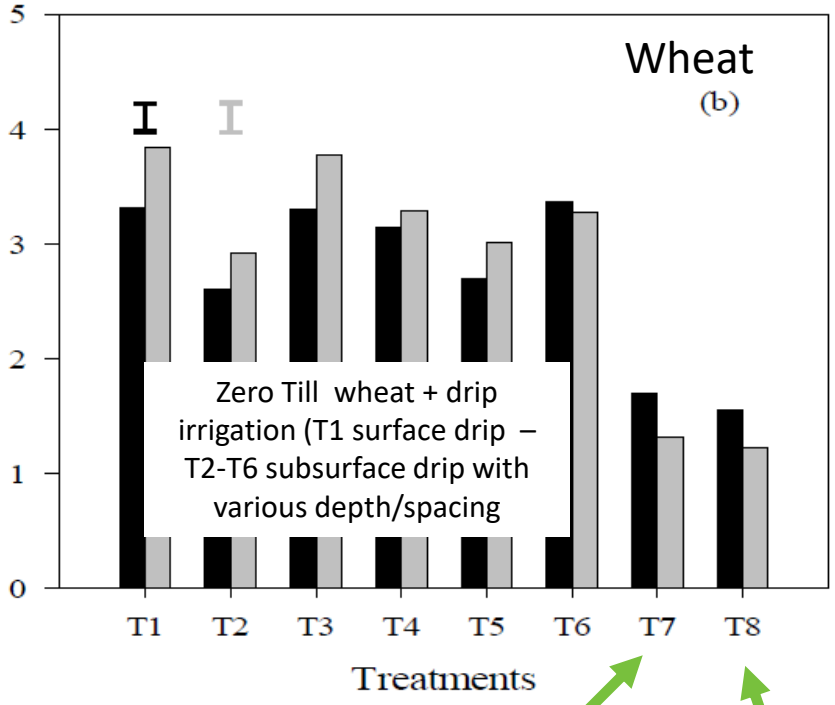
Effect of residue mulch, and drip spacing and flood irrigation system on irrigation water productivity (WP_i) during two rice and wheat growing seasons (BISA station, Ludhiana) (Jat et al. submitted)





Zero Till DSR + flood irrigation

conventional puddled transplanted rice + flood irrigation

Zero Till Wheat + flood irrigation

conventional till wheat + flood irrigation

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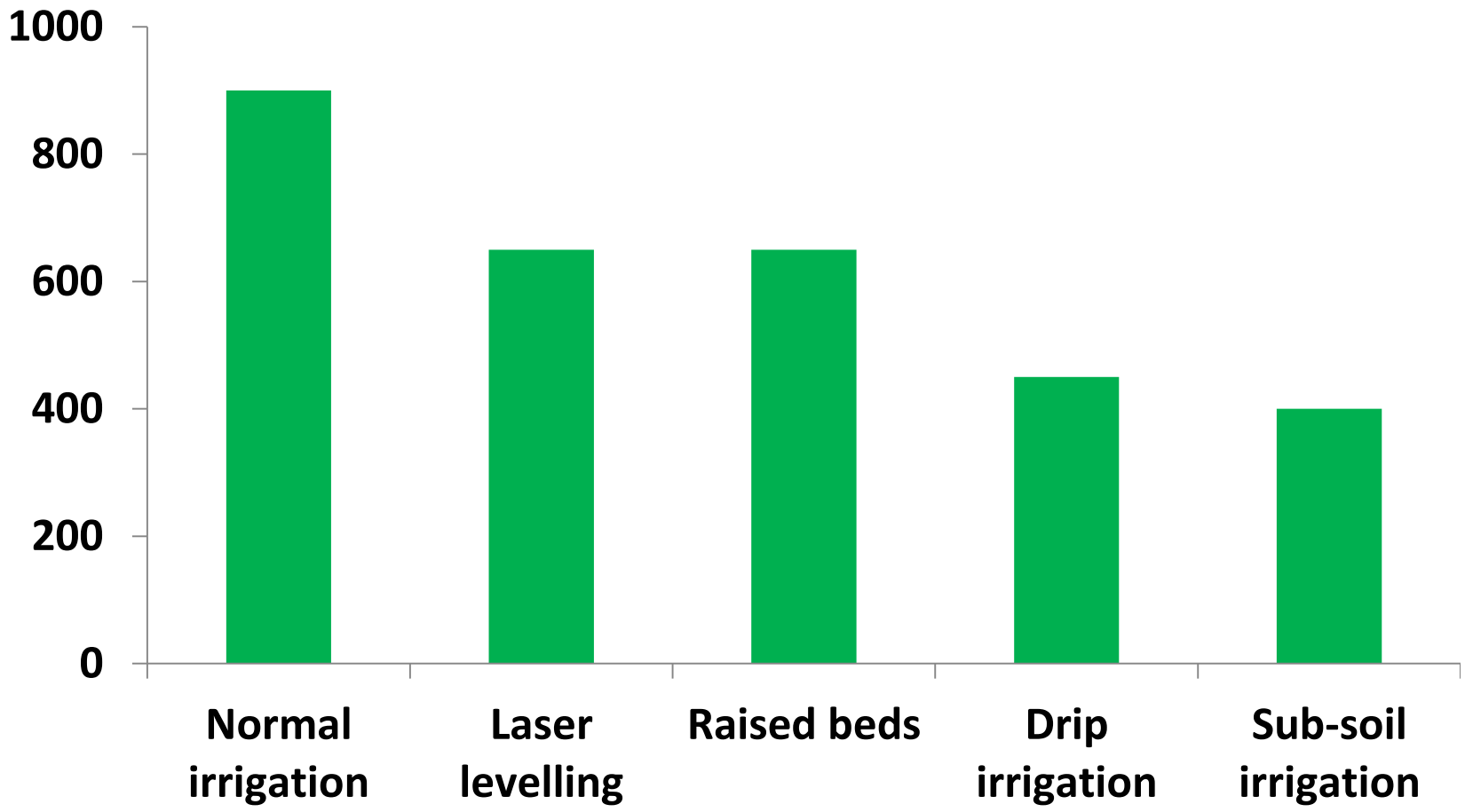
Water (liter) needed to produce 1 kg wheat with various irrigation systems



Source: Compiled by H.J. Braun form various sources

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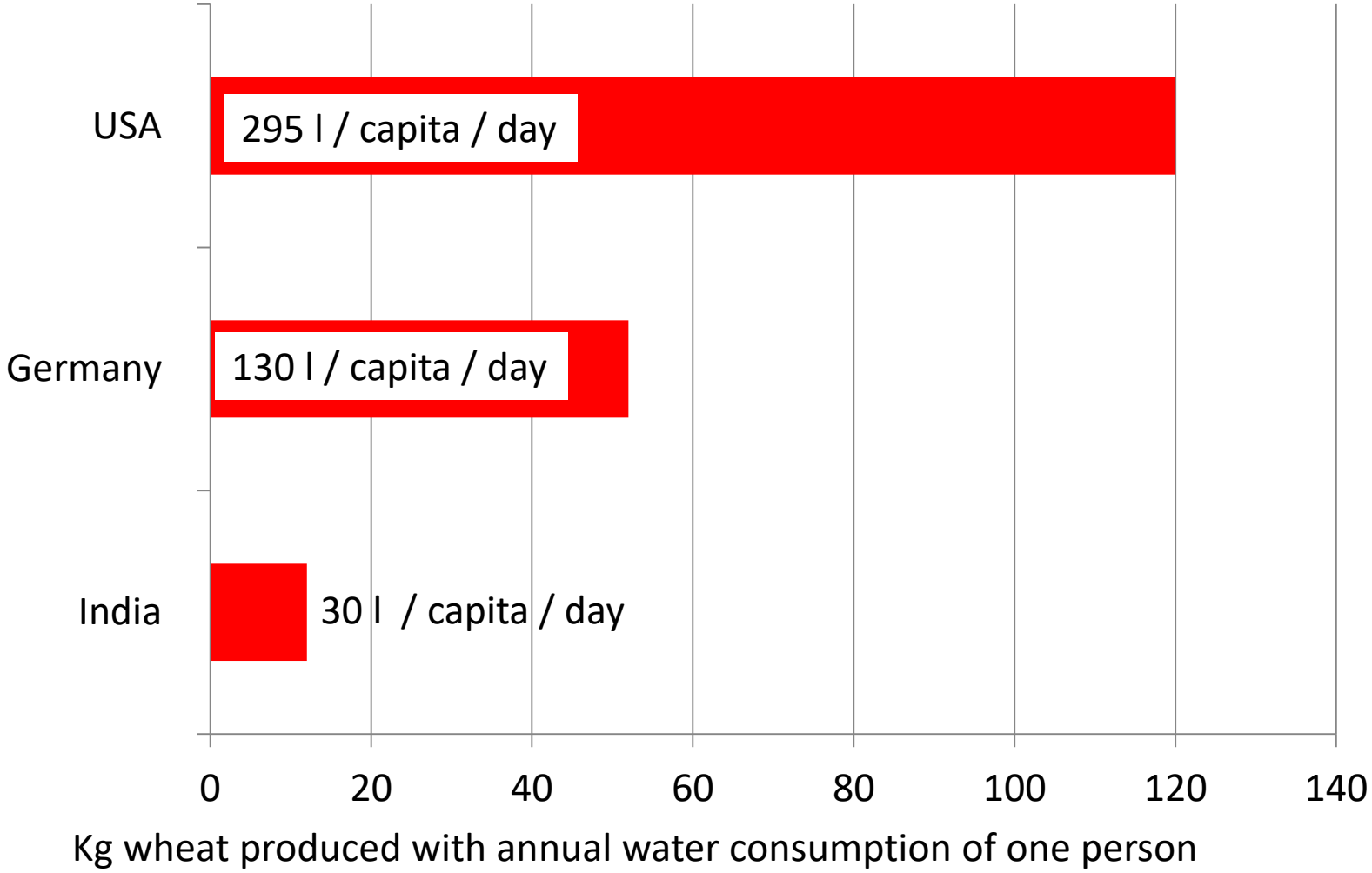
Wheat (kg) produced with annual per capita water consumption of one person



Investments needed to upgrade irrigation systems: 1 tn $ (FAO 2011)

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Summary of case studies on Wheat Yield Progress

Yield Gap Closure with

Genotype
Agronomy
Policy

Region (Wheat MegaEnvironment)	Estimated farm or potential yield (t/ha) and yield gap (%) in 2010		
	FY	PY	Yield gap (%)
Spring wheat regions (some examples)			
Yaqui Valley, Mexico (WME1)	6.4	9.0	**41**
Punjab, India (WME1)	4.5	7.0	**56**
Western Australia [b] (WME4)	1.8	2.6	**44**
North Dakota,[b] USA (WME6)	2.5	4.0	**60**
Winter wheat regions (some examples)			
Shandong and Henan (WME10)	5.8	8.8	**52**
United Kingdom (WME11)	8.0	10.7	**34**
Kansas,[b] USA (WME12)	2.8	3.8	**36**
Average all cases (n = 12)	**4.43**	[h]na	**48 ± 4**
After weighting for WME production (WME 1 =23%, WME 6 = 13%, WME 11 = 38%)			
World	**3.0**	**4.5**	**50**

Wheat Yield Gap Small in LDC compared to Rice and Maize

Source: Fischer et al (2014)

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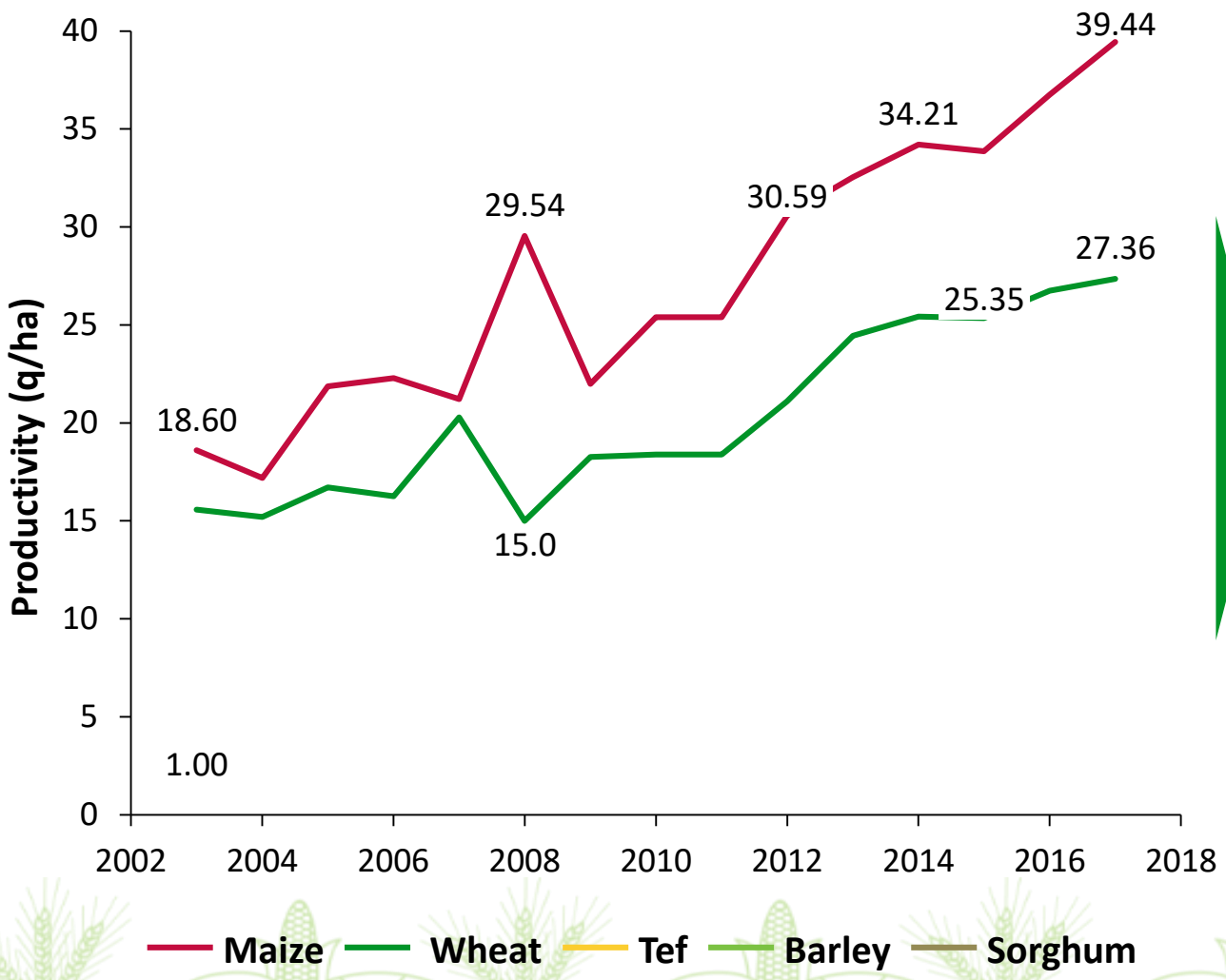
GAP - Productivity has consistently grown for major cereals

Trends in productivity (q/ha) of major cereals in Ethiopia



Maize	• 212%
Wheat	• 175%

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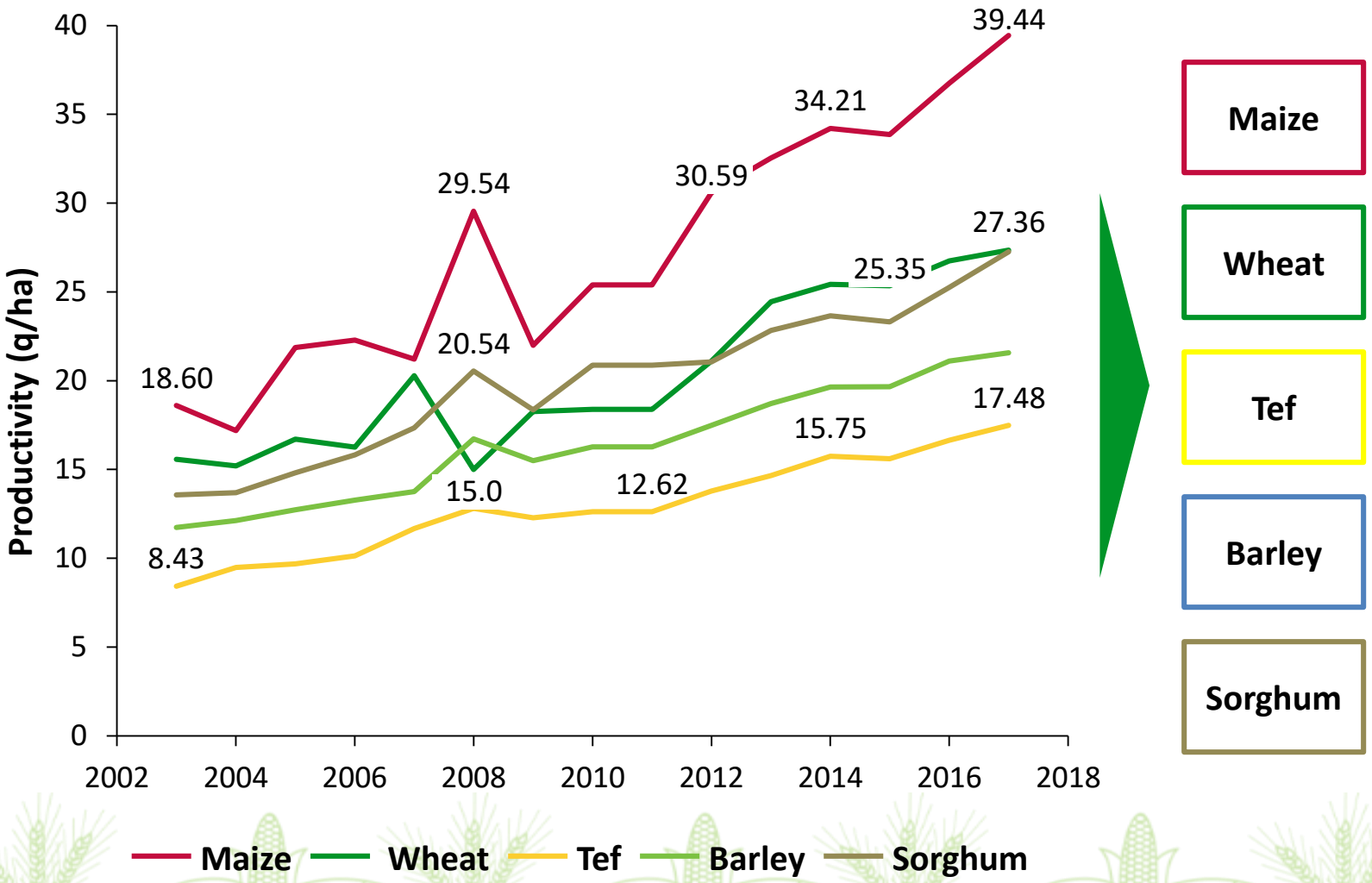
GAP - Productivity has consistently grown for major cereals

Trends in productivity (q/ha) of major cereals in Ethiopia



Maize
Wheat
Tef
Barley
Sorghum

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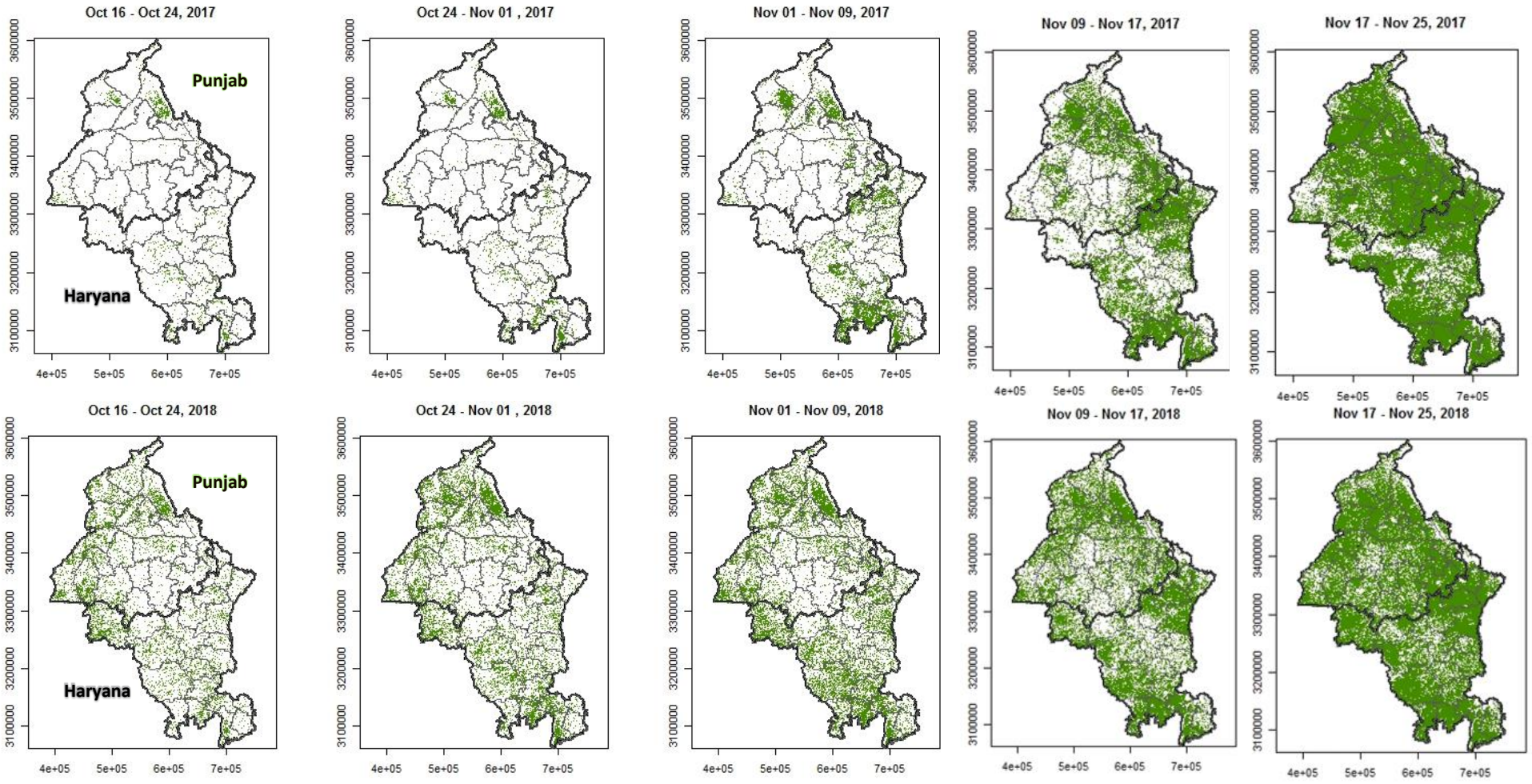
My personal key example for Genotype x Agronomy x Policy

Early sowing in Punjab and Haryana due to new varieties and Happy Seeder result in higher yields – and option for dual purpose wheat –extra fodder



Green dots: Wheat fields

Slide Amit Srivastava and Prasun Gangopadhyay, CIMMYT India

Data source: NASA

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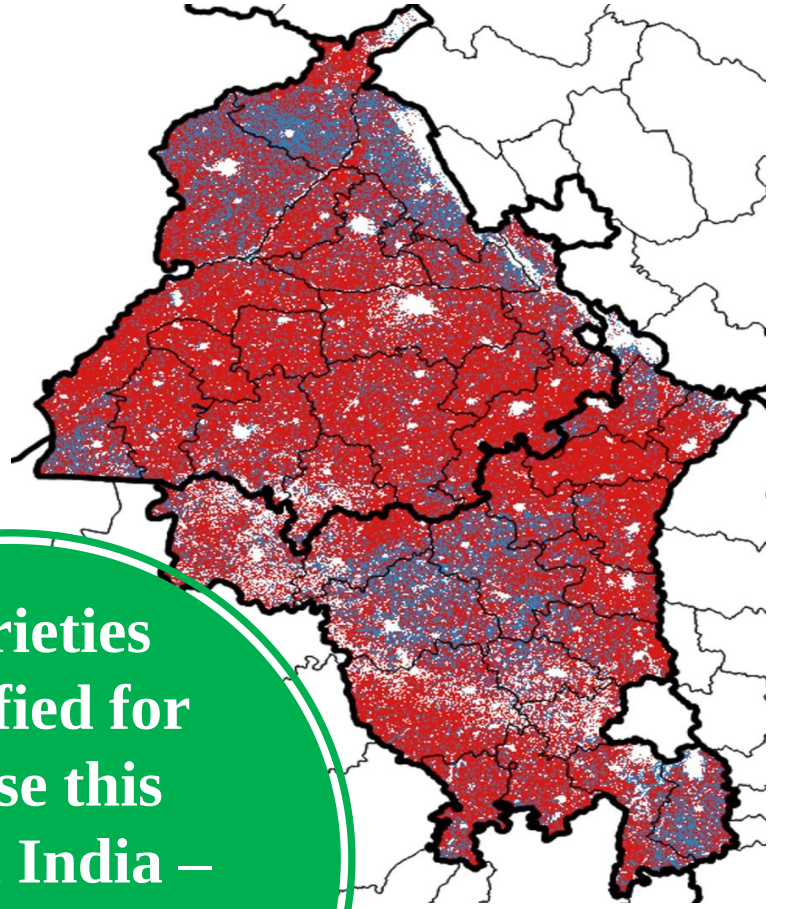
Fast track release for early (Oct) sown in NW India

- **Fields are vacated by middle of October**
- **Early sowing gives higher yield – up to 9 ton/ha**
- **Early sowing can use residual moisture of monsoon and can escape terminal heat**
- **There are machines available tha plant under rice residue and ca straw burning**



22% wheat under CA

der Singh, CIMMYT, 2020

3 varieties identified for release this year in India – DBW 303, DBW 187, WH 1270

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Green Revolutions – all based on N

1st Green Revolution – 1840 Guano NPK from Chile/Peru

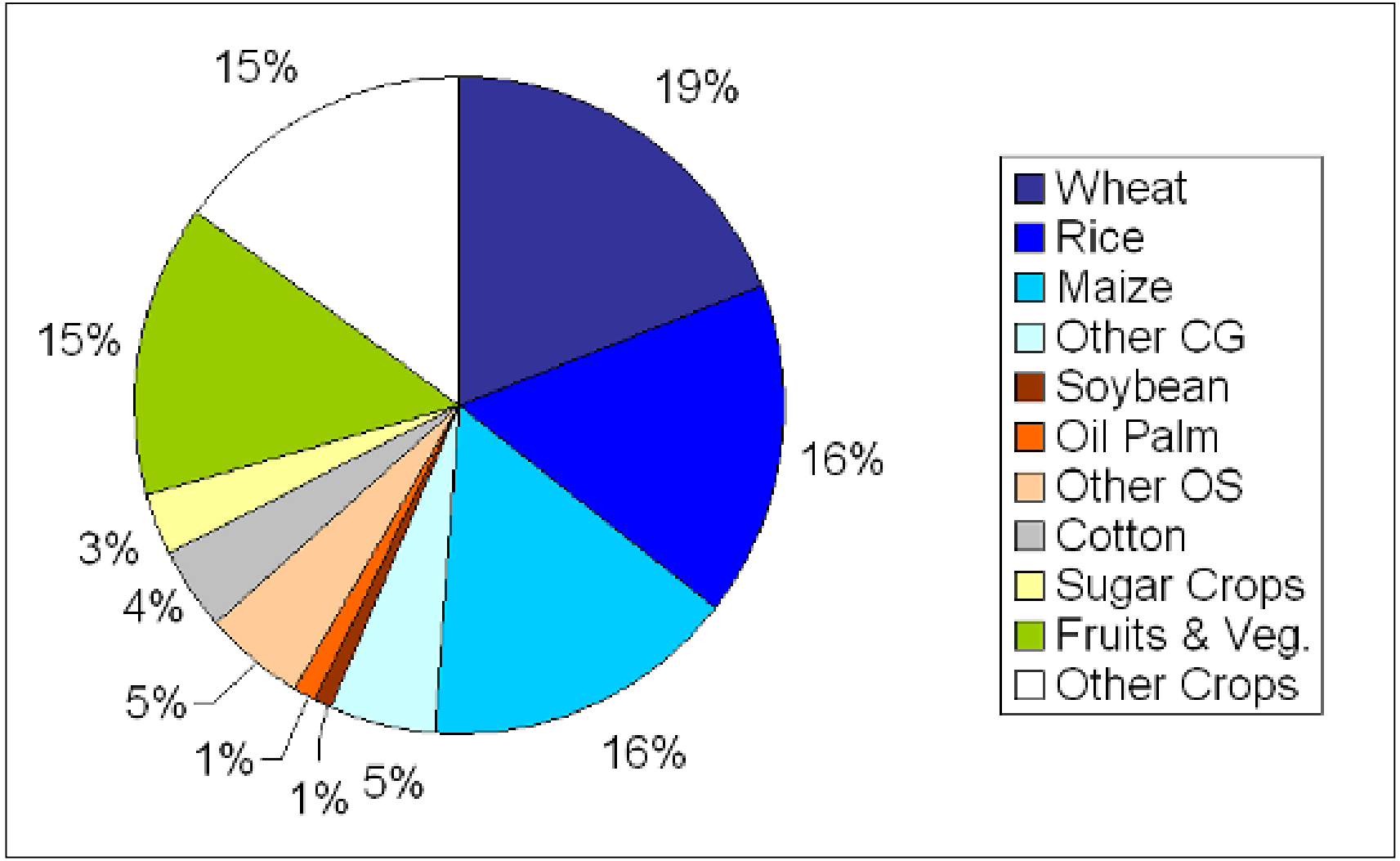
2nd Green Revolution – 1910 Haber Bosch – N – synthesis

3rd Green Revolution – 1967 semi-dwarfs utilize more N

4th Green N Revolution needed
to feed 9.5 billion, with how little N can this be done

Agronomy x Fertilizer Formulation x Genetics x Microbes
Root Research

CIMMYT



China, India, Pakistan (50%). Heffer, P. 2009. Assessment of Fertilizer Use by Crop at the Global Level 2006/2007-2007/08. International Fertilizer Industry Association.
33% worldwide efficiency. Raun W.R. and G.V. Johnson. 1999. Improving Nitrogen Use Efficiency for Cereal Production. Agronomy Journal. 91:357:363
Up to 65% efficiency in the US. Roberts, T. 2008. Improving Nutrient Use Efficiency. Turk J. Agric For 32:177-182

CIMMYT

Global N application and crop yield – 1961 – 2013

1961 11 mlln t

2013 115 mlln t of which 75% in developing countries -mainly Asia

NUE in wheat has not changed since 1999

1999: 33% 2015 35%

Omara, et al., 2019

N-application increased 10 times

Crop yield increased 3 times

Source: FAO, 2015; Hirel et al., Sustainability, 2011 vol 3, 1452-1485

CIMMYT

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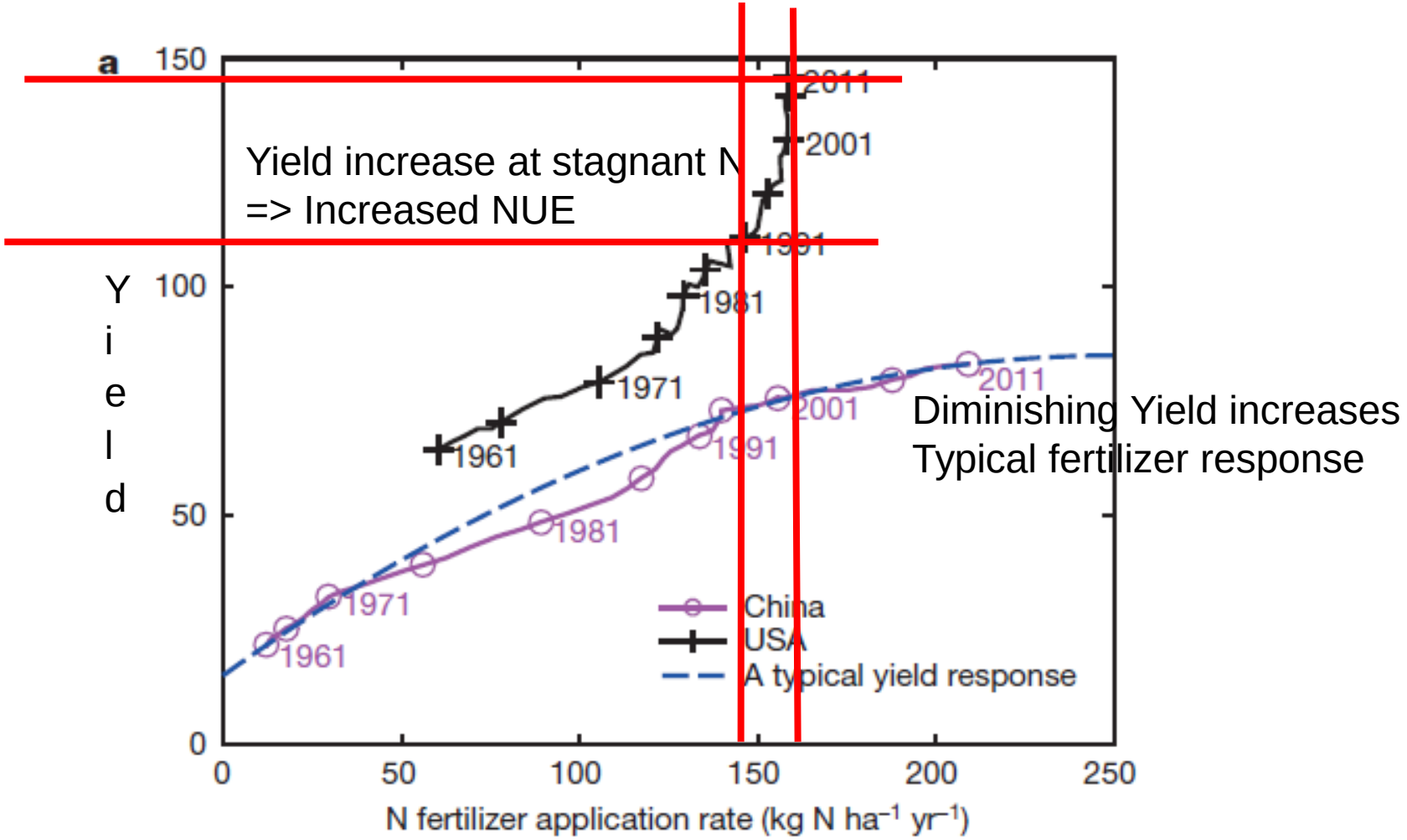
N-application increased 10 times
Crop yield increased 3 times

Source: FAO, 2015; Hirel et al., Sustainability, 2011 vol 3, 1452-1485

CIMMYT

N application to maize in China and USA



Zhang et al., 2015. Nature. 15743

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New Approaches to Breeding

- Accelerating Genetic Gains in Maize and Wheat – BMGF, FCDO, USAID, USDA – target regions S-Asia and E-Africa
- Focus on reducing cycle time
- Breeding decisions based on Genomic Estimated Breeding Values
- Rapid Bulk Generation Advancement – Speed Breeding – 3 or 4 years
- Rapid Cycle Recurrent Selection – Parents selected from F5
- Selection Index for yield and Zn
- Requires input from many disciplines quantitative genetics, bioinformatics
- CMMYT plans to base a scientist in India to work closely with Indian colleagues to fully exploit the potential of this approach
- Will continue shuttle and compare in a few years costs, selection efficiency and most important performance of germplasm

Expanding India-CIMMYT/BISA collaboration in Wheat Breeding to benefit smallholder farmers

- Piloting of rapid cycling, quantitative genetics and molecular breeding to enhance genetic gain for grain yield and grain Zn
- Earlier and increased phenotyping in target population of environments (TPEs-S-Asia) beyond selection environments (SE) in Obregon

  GS trials currently grown at 3 BISA sites in India, 3 in Pakistan, 2 in Nepal and 1 in Bangladesh
- Early access of elite lines & data to participating partners for use as parents, or variety release for faster delivery of genetic gain

In both the AGG & Zn-mainstreaming projects we seek partnerships with 3-4 institutions in each TPEs for phenotyping of Stage 2 trials (180-200 entries)

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Breeding Cycle time reduction from current 2-generations/year field-based selection

'Rapid Bulk Generation Advancement' (RBGA) & 'Rapid Cycle Recurrent Selection' (RCRS) Schemes

Piloting & optimization to initiate in January 2021

1-year saved from the current 2 generation/year field- based shuttle breeding

1- 2 years saved from the current yield testing protocol

23 months (starting July each year)

- Crossing & generation advancement Toluca– Field Screenhouse
- F5 head-rows plots- selection for agronomic, leaf/stem rusts, grain traits Obregon – field

RCRS Cycle- 2 years

Select best parents using GEBV + visual phenotype

Year 3

- Seed multiplication & phenotyping for yellow/leaf rusts, Septoria tritici blotch, Genoptyping El Batan & Toluca fields (summer nurseries)
- Stage 1 yield trials (4 Managed Env.-Obregon) & seed mult. for Stage 2 testing in TPEs
  Phenotyping for agronomic traits, resistance to diseases (Mexico, South Asia, East Africa: yellow rust, spot blotch, Ug99 stem rust)

Select best parents using stage 1 YT data + GEBV (GBLUP) + phenotypic data (breeding value & selection index)

Year 4

- El Batan/Toluca/Kenya (May-October) Phenotyping for resistance to diseases, quality Trials preparation & shipment to TPEs
- Obregon- Field (Nov-May) Stage 2 yield trials (5-6 Managed Env.) & 4-5 TPE sites
  Phenotyping for agronomic traits & disease resistance.

RBGA Cycle- 3-4 years

Select best parents using stage 1 & 2 YT data + GEBV (GBLUP) + phenotypic data (breeding value & selection index)

Shuttle Breeding operates in parallel So all methods can be Compared re Costs and Germplasm Perform.

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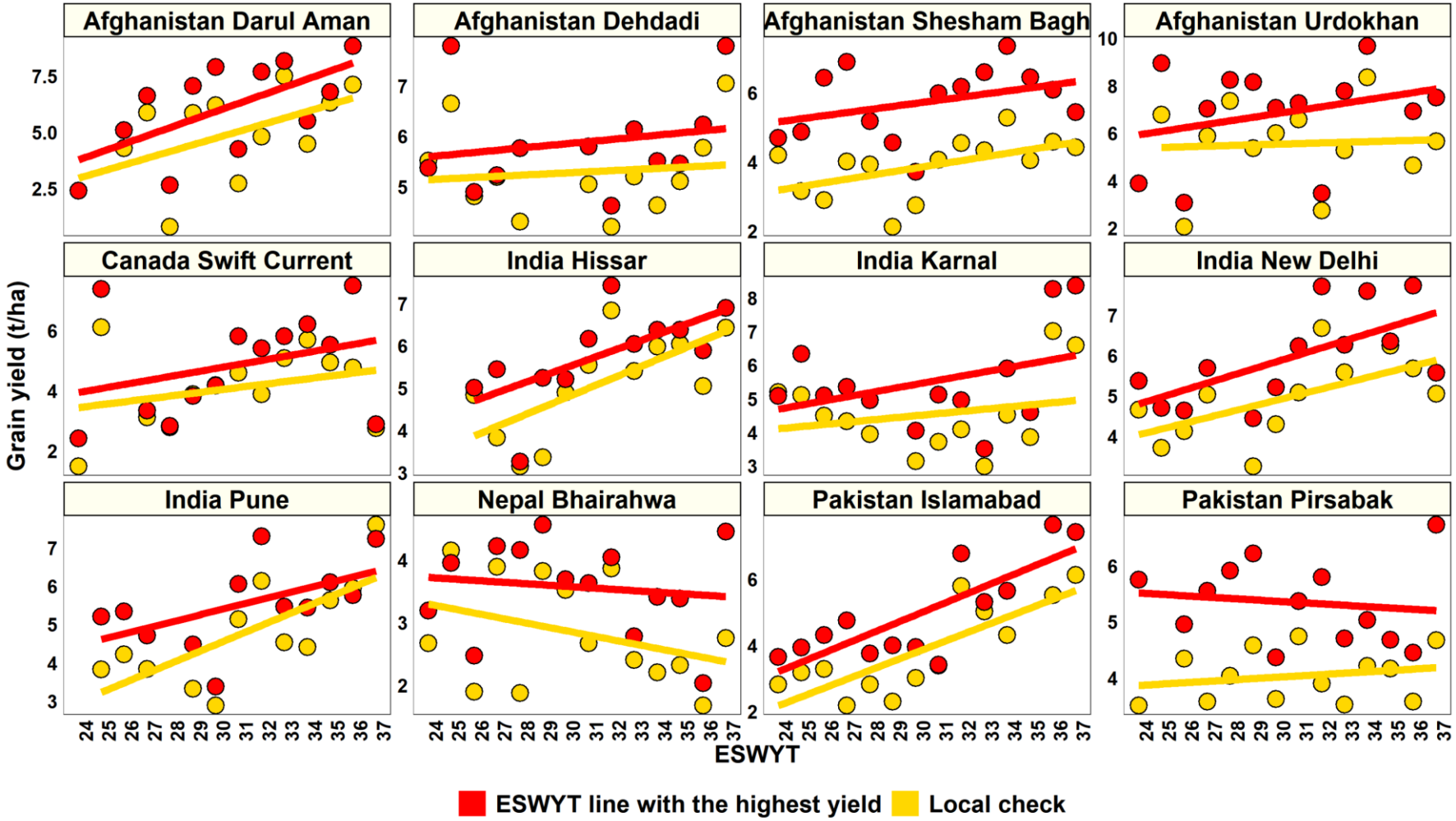
Relative grain yield performance of the highest yielding Elite Spring Wheat Yield Trial (ESWYT) line in each year over the grain yield of the local check in that year across 12 sites in the 24th to the 37th ESWYT



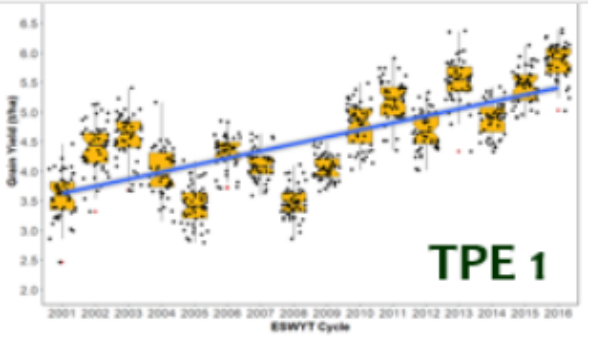
- There was a clear superiority of the highest yielding ESWYT lines over the local check in 144 out of the 152 (94.7%) site-year combinations.
- The mean increase in grain yield of the highest yielding ESWYT line over the local check in the 144 site-year combinations was 1.1 ± 0.7 t/ha (29.5 ± 28.6% increase) and it ranged from 0.03 to 3.54 t/ha (0.6 to 237.2% increase).

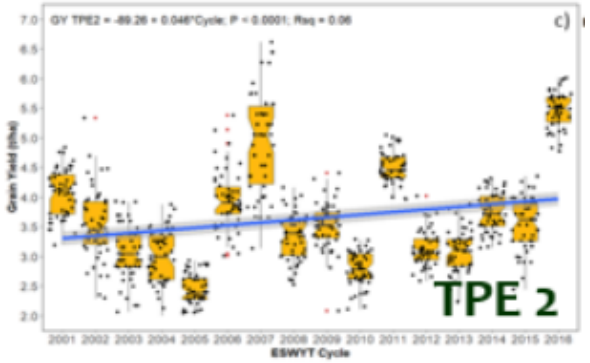
Response to selection in Obregon and genetic gain in TPEs of India

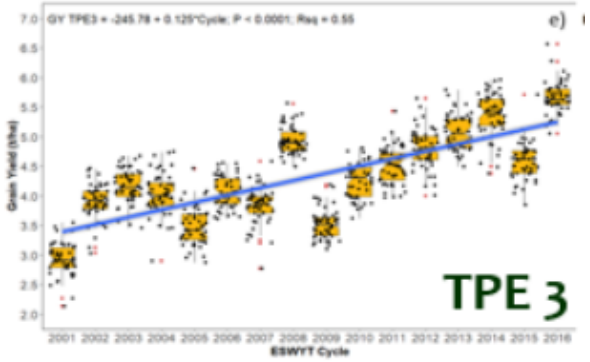
(ESWYT 2003-04 to 2017-18)

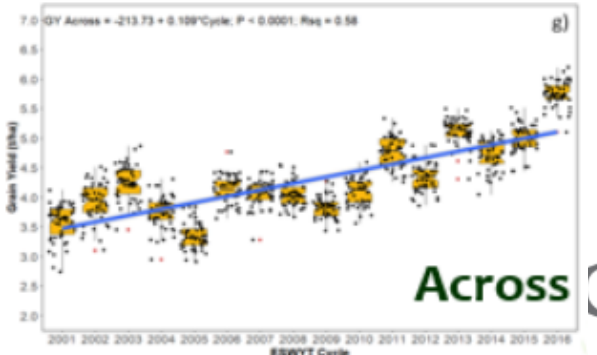
Note: ESWYT is TPE1 targeted yield trial

	Grain yield progress Kg/ha/year
TPE1	119
TPE2	46
TPE3	125
Across	109



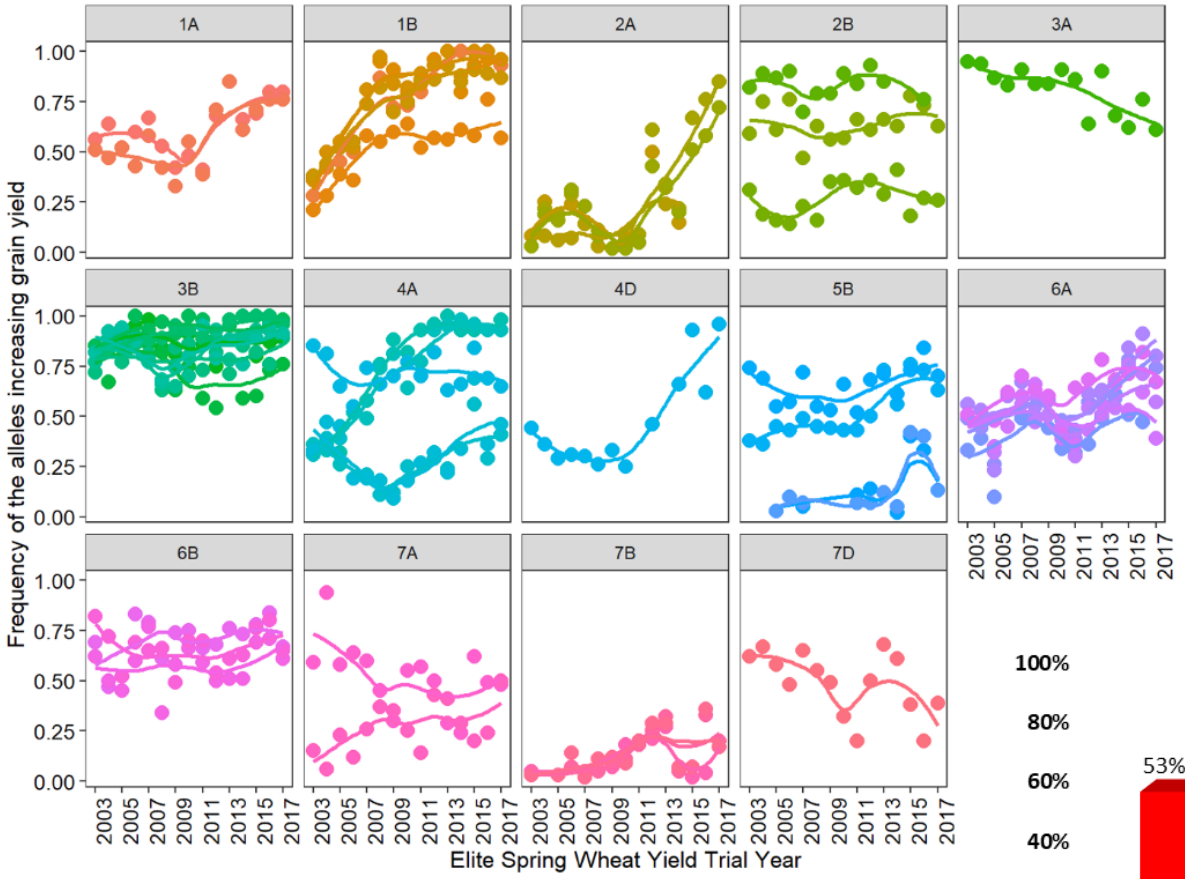






CIMMYT

Molecular tracking of favorable allele frequencies and the effect of selection in 15 years of wheat breeding at CIMMYT



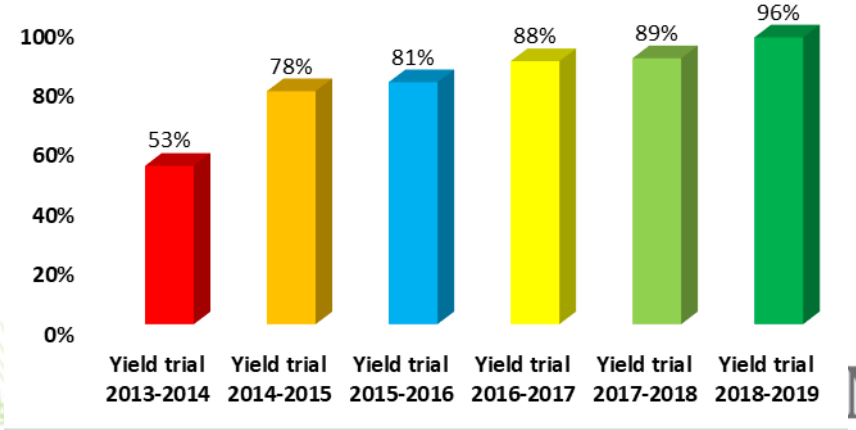
Trends in the grain yield favorable allele frequencies in the globally distributed Elite Spring Wheat Yield Trials

The favorable alleles for several grain yield associated markers have reached fixation indicating the effective impact of grain yield selection at CIMMYT, and also emphasize:

(i) the need for a continued effort of the breeders in introducing novel sources of favorable alleles and

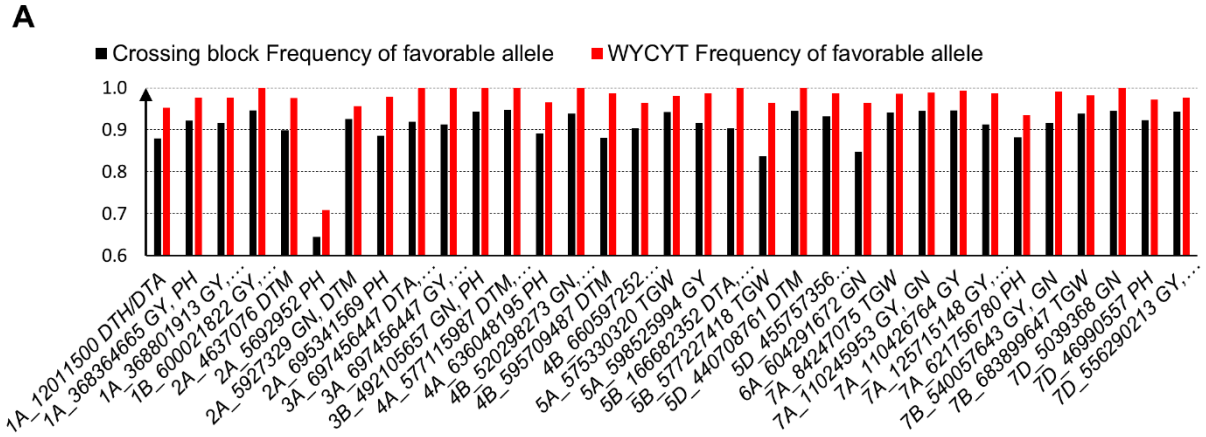
(ii) the importance of integrating genomic tools in achieving accelerated fav. allele enrichment.

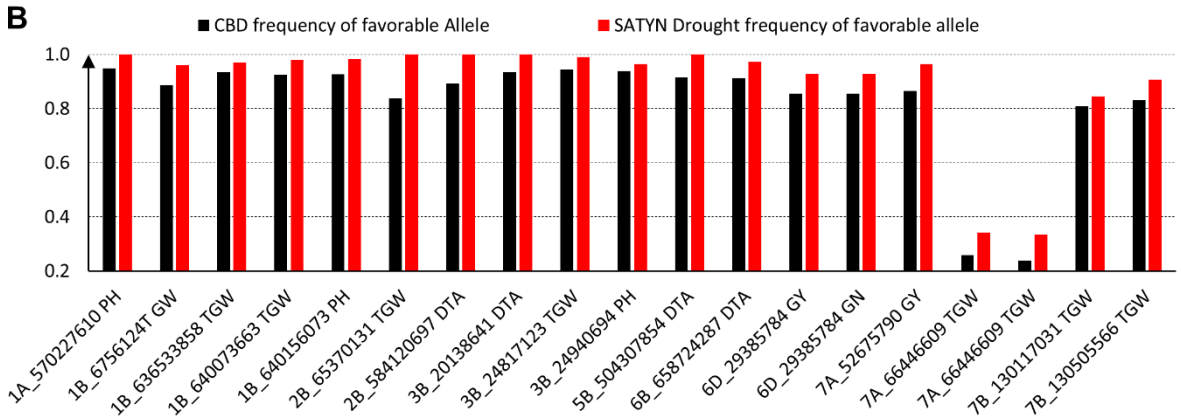
Trends in the 2NS translocation frequencies in CIMMYT's yield trial germplasm (<9,000 lines each year)

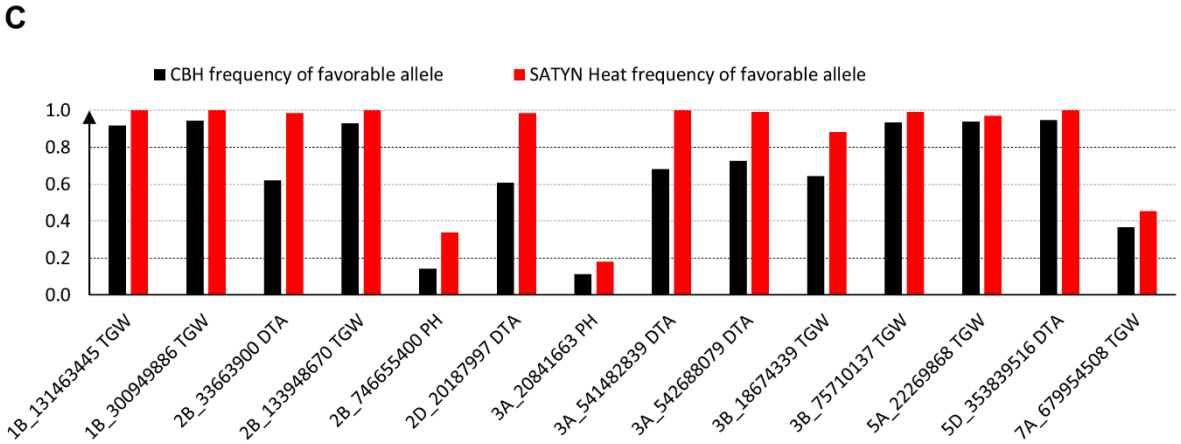


MMYT

Frequency







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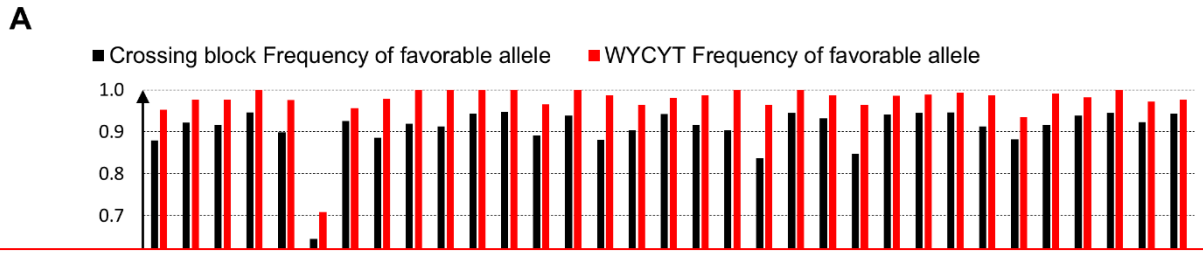

Main points

- Physiological pre-breeding is an effective method to incorporate complex traits from exotic germplasm into elite lines

- Molecular markers will increase the efficiency to fix favorable alleles and genes in later generations

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Selection Traits in Spring Bread Wheat Product Profiles

	Product Profile/Market Segment					
	Breeding Program 1		Breeding Program 2			
	1. Hard White-Optimum Environment	2. Hard White-Heat Tolerant Early Maturity	3. Hard White-Drought Tolerant Normal Maturity	4. Hard White-Drought Tolerant Early Maturity	5. Hard White-High Rainfall	6. Hard Red – High Rainfall
	HW-OE	HW-HTEM	HW-DTNM	HW-DTEM	HW-HR	HR-HR
Trait	2x	2x	1x	1x	0.75x	0.25x
High and stable yield potential	XXX	XXX	XXX	XXX	XXX	XXX
Water use efficiency/Drought tolerance	X	X	XXX	XXX	XX	XX
Heat tolerance	XX	XXX	XX	XXX	X	X
End-use quality	XXX	XXX	XXX	XXX	XXX	XXX
Enhanced grain Zn (and Fe) content (new mainstreaming trait)	XXX	XXX	XXX	XXX	XXX	XXX
Stem rust (Ug99 & other)	XX	XX	XX	XXX	XXX	XXX
Stripe rust	XXX	XX	XXX	XX	XXX	XXX
Leaf rust	XXX	XXX	XXX	XXX	XX	XX
Septoria tritici blotch	-	-	XXX	-	XXX	XXX
Spot blotch	X	XXX	-	X	-	-
Fusarium – head scab and myco-toxins	-	-	-	-	XX	XX
Wheat blast- new threat in South Asia	X	XXX	X	X	X	X
Maturity	Normal-late	Early	Normal	Early	Normal	Normal

Importance: X= low, XX= moderate, XXX= high

Common agronomic traits: *plant height, stem strength, leaf health, spike fertility, grain size & plumpness, etc.*

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Selection Traits in Spring Bread Wheat Product Profiles

	Product Profile/Market Segment					
	Breeding Program 1		Breeding Program 2			
	1. Hard White-Optimum Environment	2. Hard White-Heat Tolerant Early Maturity	3. Hard White-Drought Tolerant Normal Maturity	4. Hard White-Drought Tolerant Early Maturity	5. Hard White-High Rainfall	6. Hard Red – High Rainfall
Tr						HR
Hi						x
W						X
to						
He						
En						X
En						
(n						X
St						X
St						X
Le						
Se						X
Sp						
Fu						
W						
Maturity	Normal-late	Early	Normal	Early	Normal	Normal

Importance: X= low, XX= moderate, XXX= high

1. These product profiles need to be verified with our NARS partners and updated as required in the future

2. Gender intentionality (traits preferred by women farmers) need to be explored and integrated

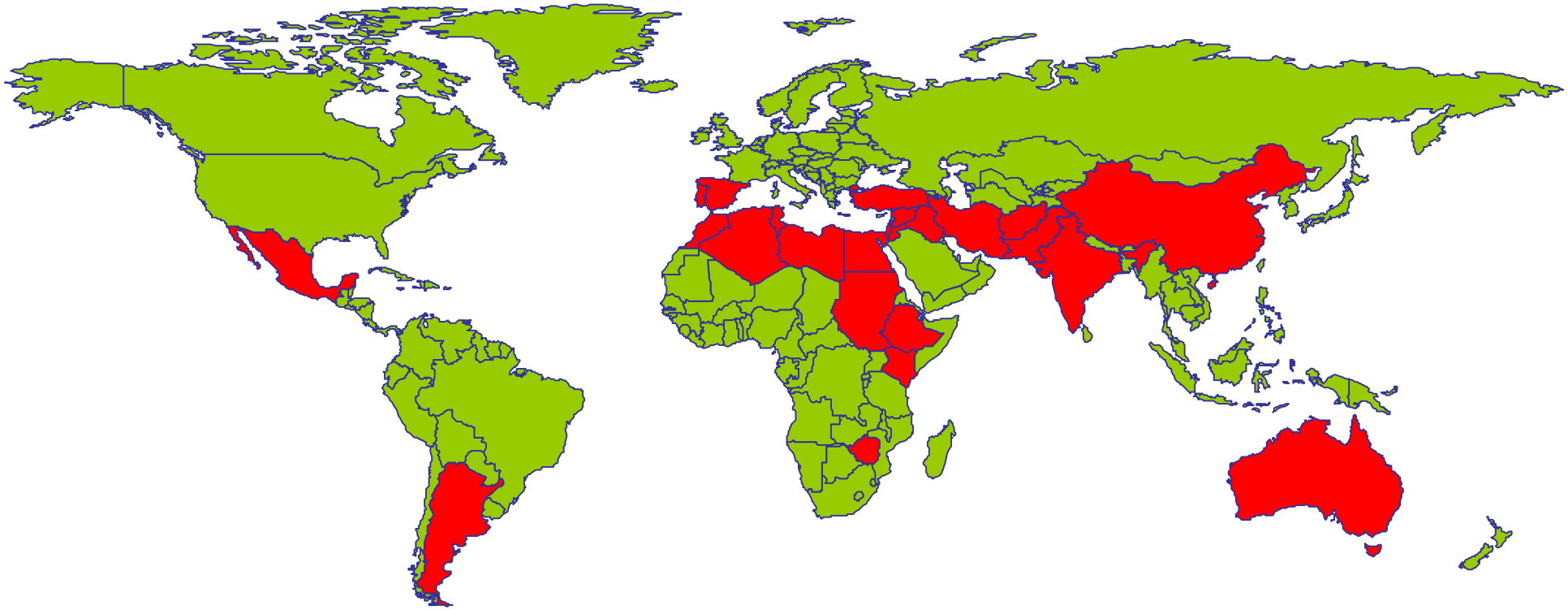
Common agronomic traits: *plant height, stem strength, leaf health, spike fertility, grain size & plumpness, etc.*

CIMMYT MR

Happy Gene Package

Wide Adaptation – Yield Stability – Disease Resistance – Tolerance to abiotic stresses – Quality

Countries that often release same line or sister lines



Need to keep desirables alleles as block

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Wheat as a Global Crop requires Global Co-ordinated Responses

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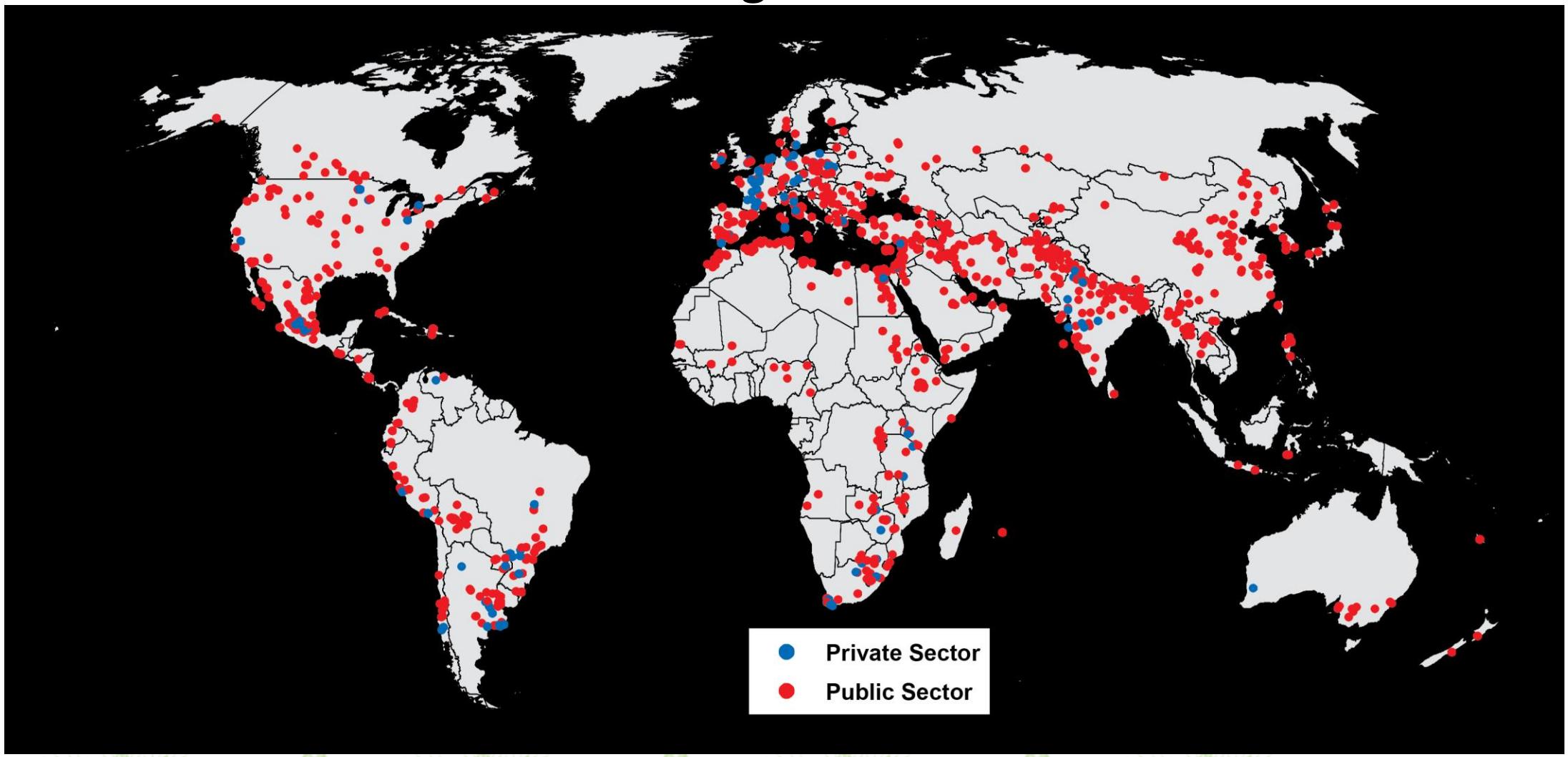
Private and Public Sector Partners in International Wheat Improvement Network (IWIN): Key to Delivering Impacts

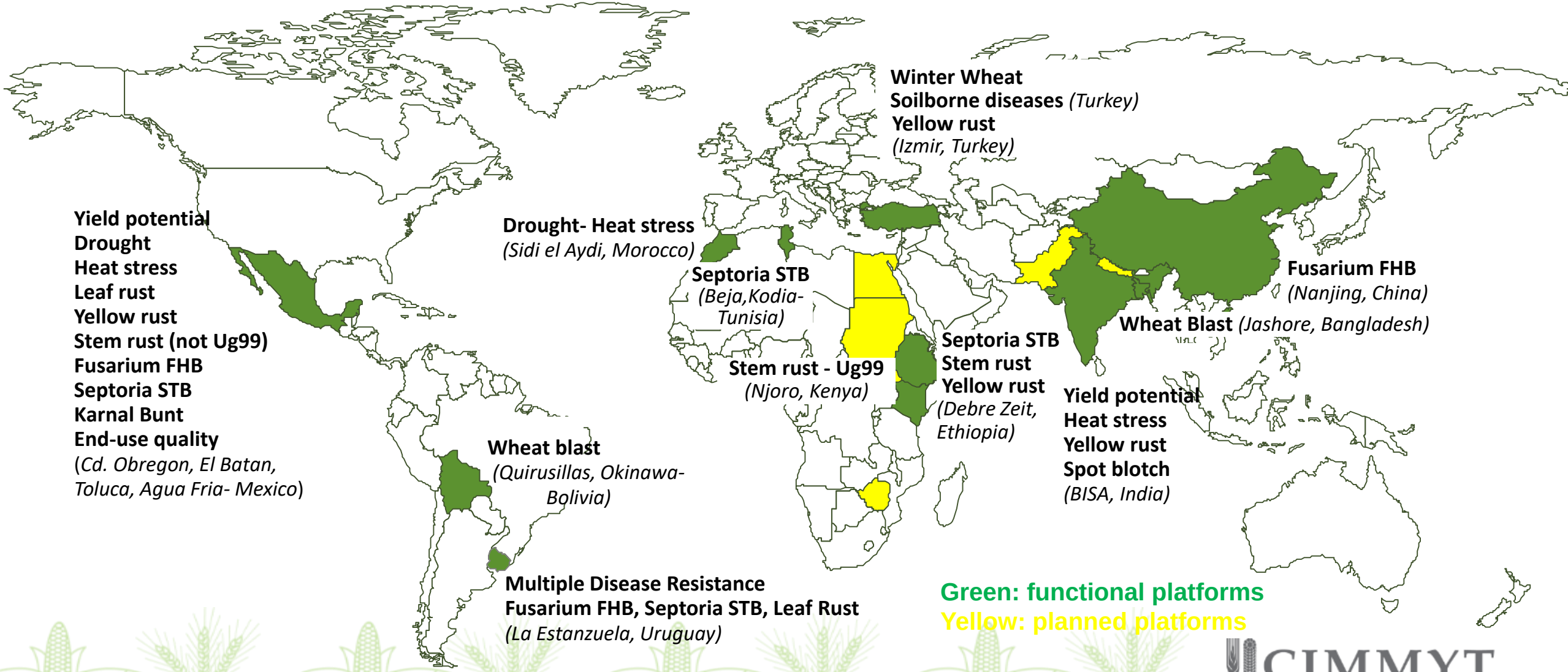
Locations receiving CIMMYT nurseries



Source: K. Sonders CIMMYT

CIMMYT

Global network of precision field-based wheat phenotyping platforms developed with co-investing national agricultural research institutes (http://wheat.org)



CIMMYT

IWYP International Wheat Yield Partnership

Research to Deliver Wheat for the Future

Unlocking the Genetic Yield Potential of Wheat

INTERNATIONAL WHEAT YIELD PARTNERSHIP

IWYP'S GOAL IS TO INCREASE THE GENETIC YIELD POTENTIAL OF WHEAT BY 50% IN 20 YEARS

Public Members

Australia	GRDC
Canada	AAFC
France	INRAE
India	DBT
Mexico	CIMMYT
Mexico	SADER

Syngenta Foundation

Wheat Initiative

Private Companies

BASF

KWS

Limagrain

LongReach

Mahyco

Pioneer

RAGT

SeedCo

Syngenta

CIMMYT

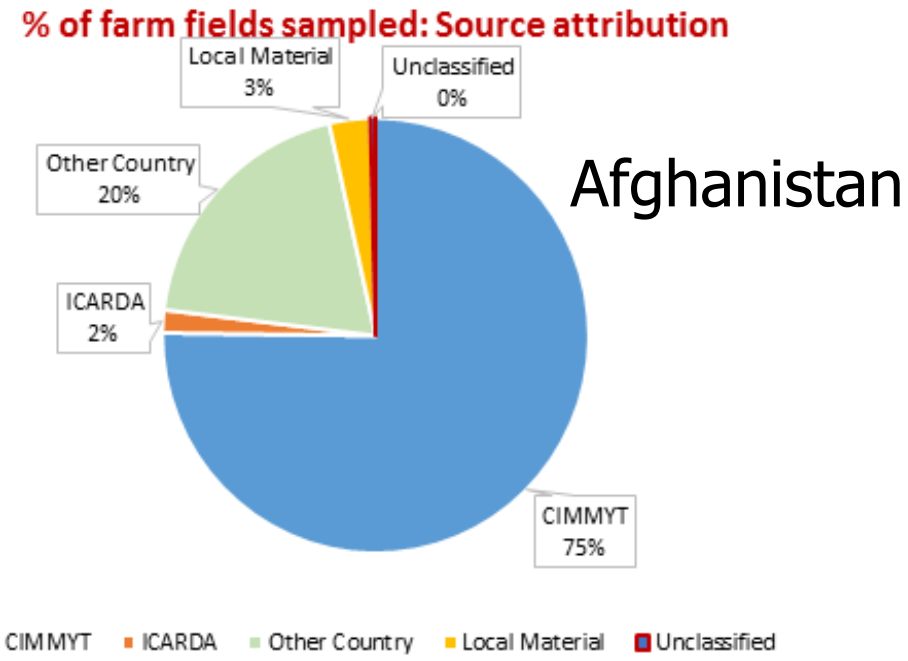
Ethiopia and Afghanistan Wheat Impact studies using DNA Fingerprinting

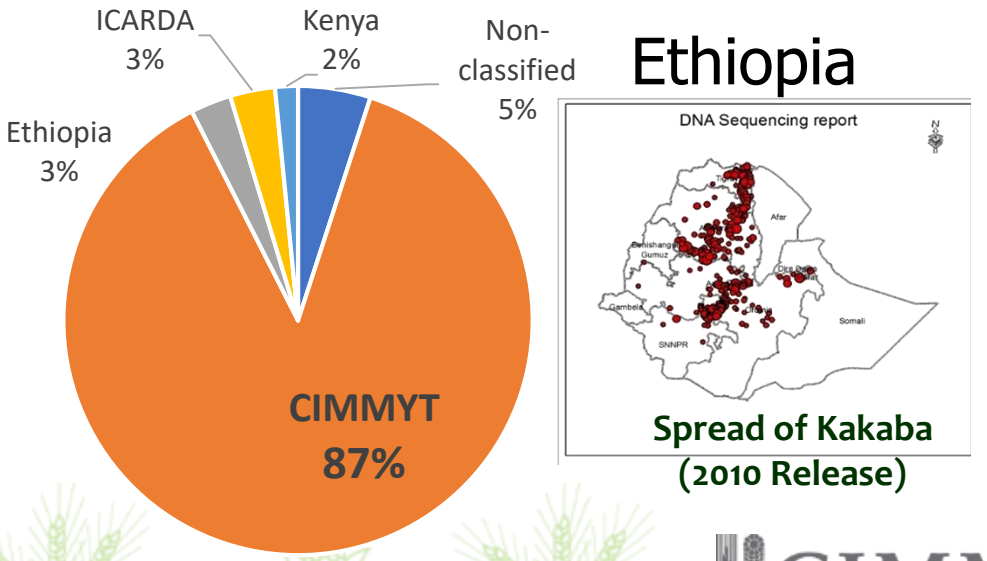
Afghanistan:

- **75% of samples CIMMYT derived varieties**
- **58% of farmers had correct variety name**

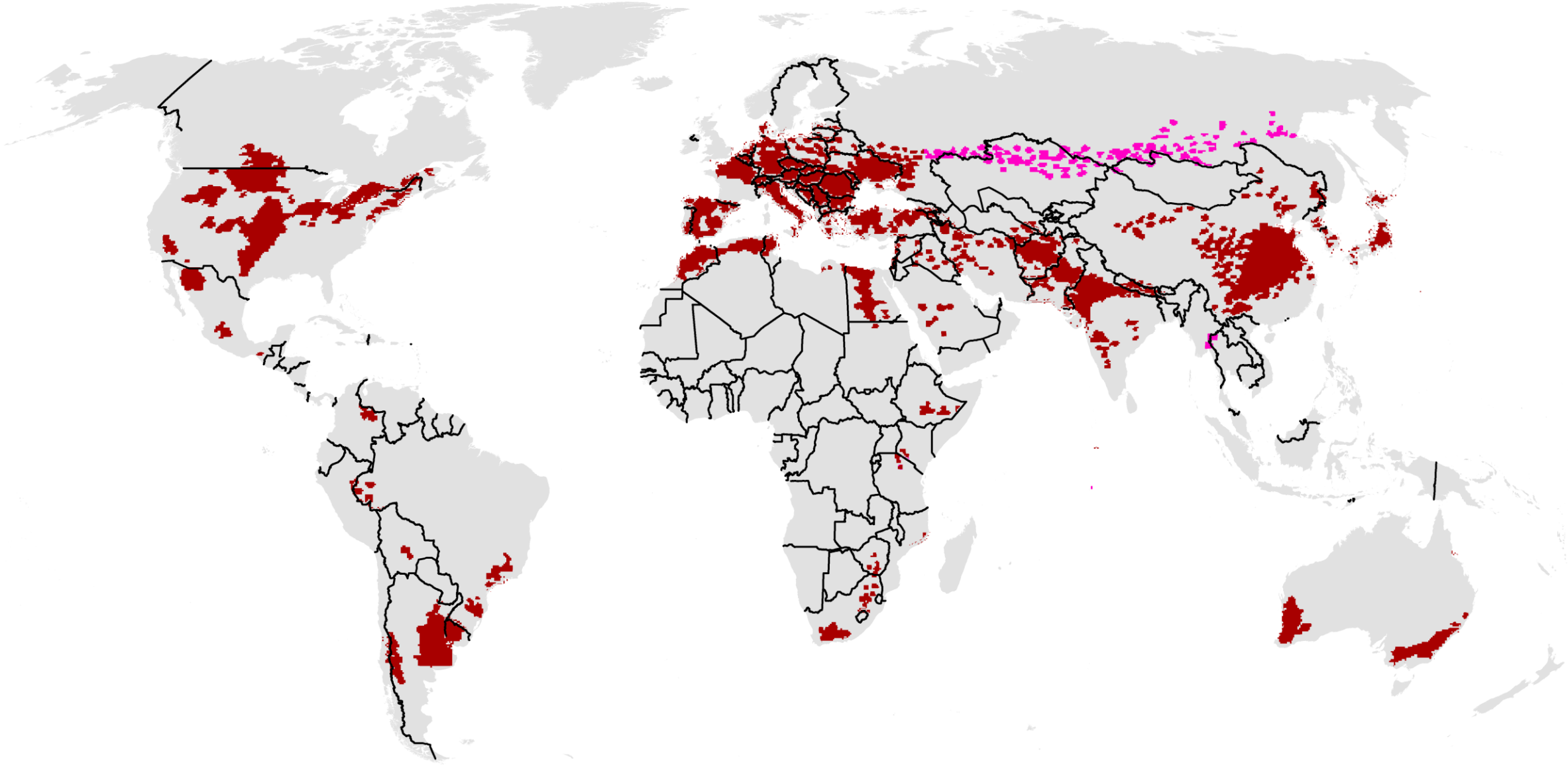
Ethiopia

- **89% of samples from all provinces CIMMYT derived varieties**
- **55% of sampled households growing rust resistant varieties**
- **45% of samples varieties released in last 10 years**
  61% released since 2005





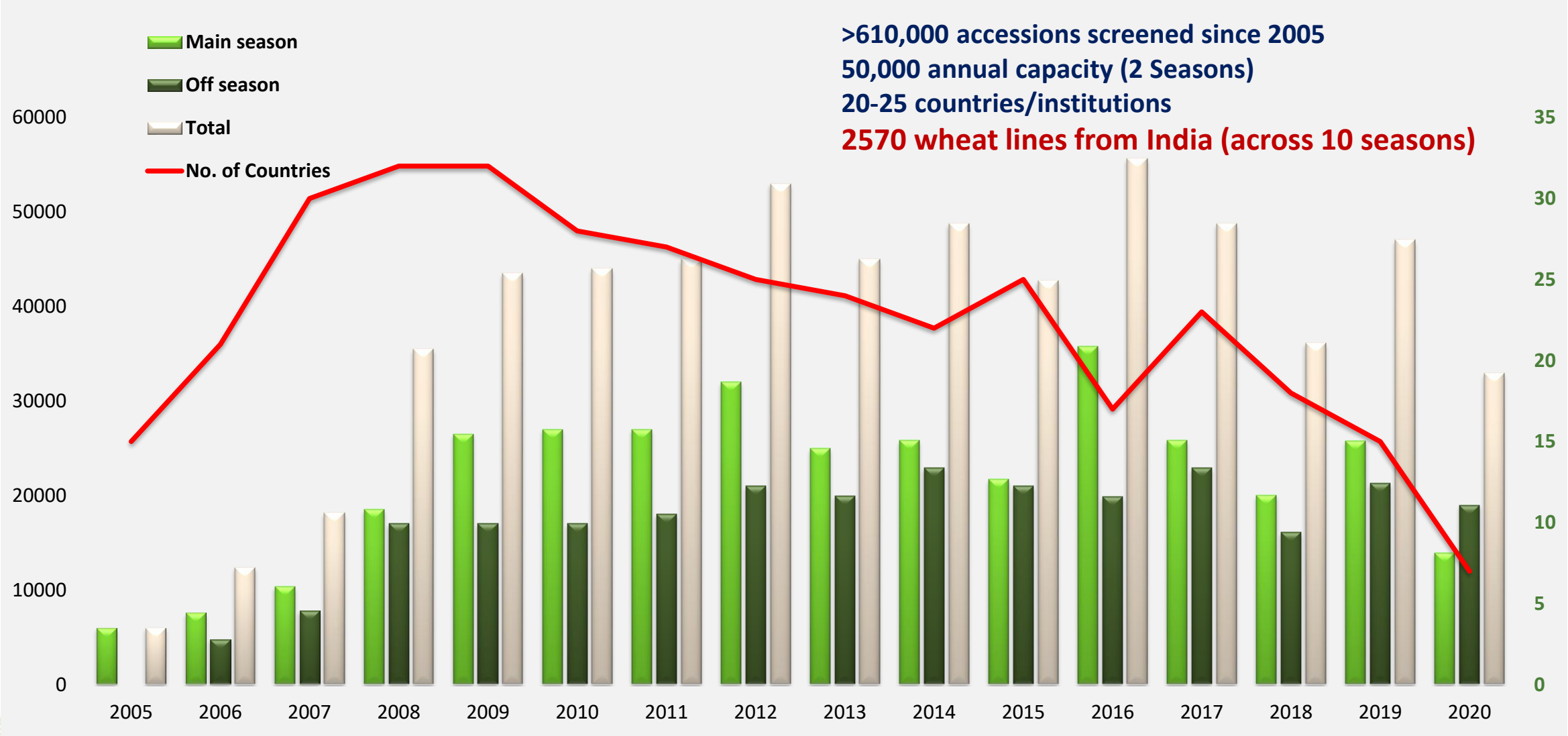
CIMMYT



Wheat areas where Stem Rust would be a problem without resistant cultivars

Major Minor

Wheat accessions phenotyped during 2005-2020 for Ug99 resistance at Njoro (Kenya) and participating countries, in partnership with KALRO



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Rust control in India

Leaf Rust: Last epidemics around 1980 – Sonalika epidemic
Stem Rust: Last major epidemics in late 70s – ca 200 mlln $ loss
Today, 7 mlln ha rust prone area sown with resistant varieties

Leaf rust and stem rust are basically controlled in India through resistant varieties which are maturing earlier and consequent low inoculum built up

Use of rust genes with pleiotropic effects (Lr 34, 46, 67, 68, Sr2 etc)

– no complacency permitted – rust never sleeps!!!

Yellow rust remains an issue
rapid replacement of susceptible varieties and support for continuous resistance breeding

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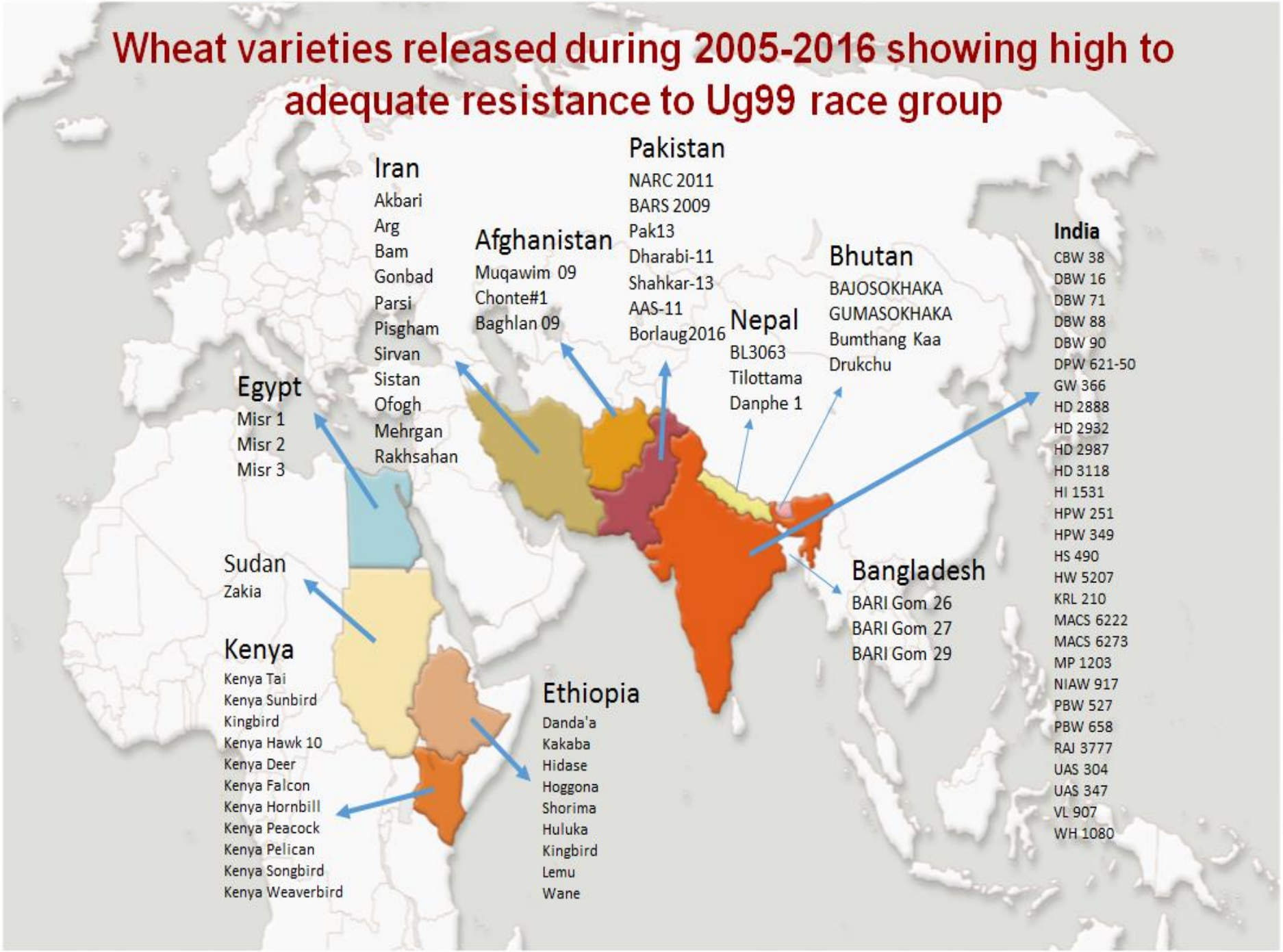
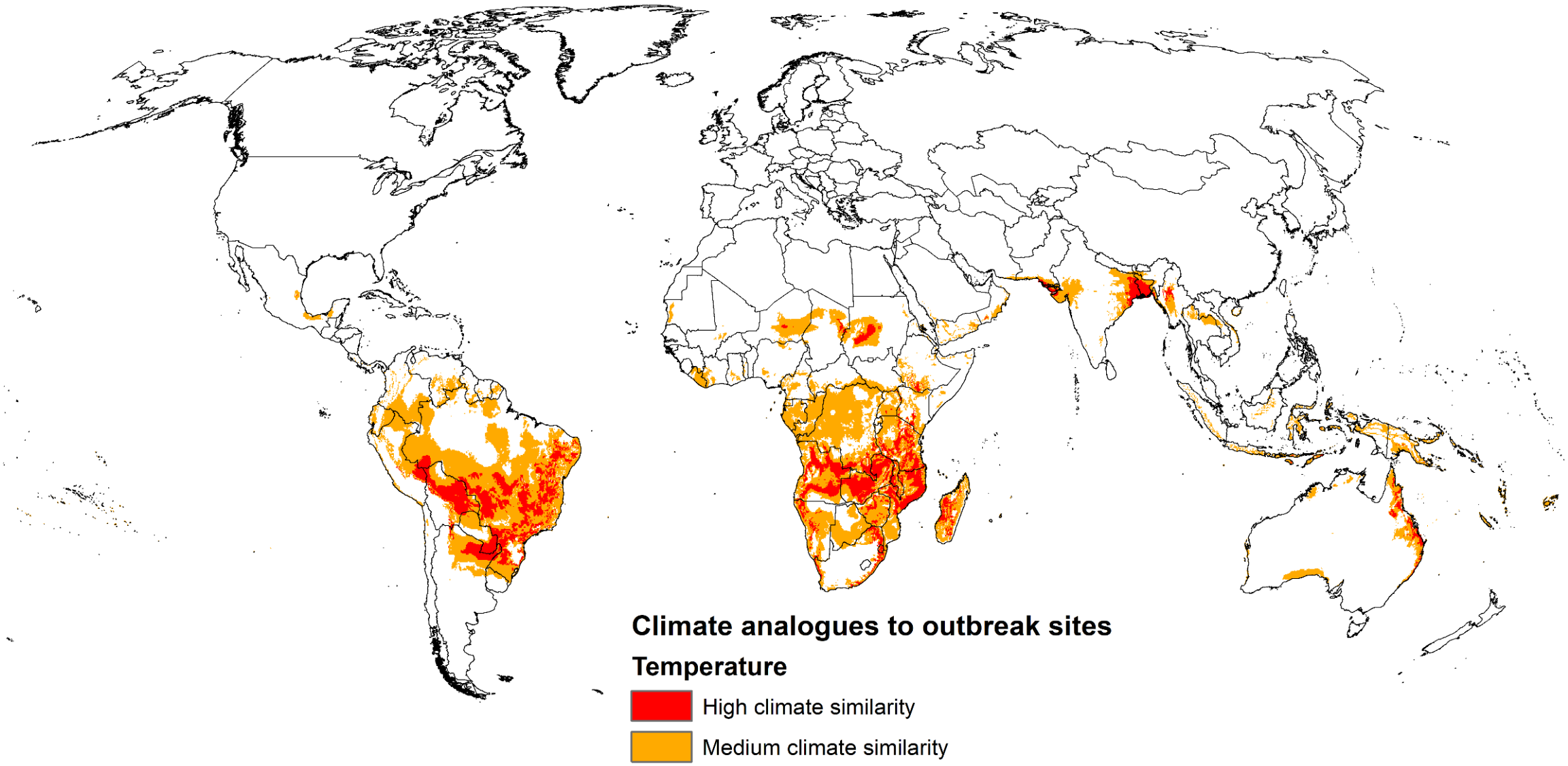
Wheat varieties released during 2005-2016 showing high to adequate resistance to Ug99 race group



IMYT

Regions with similar climate to location where Wheat Blast is reported from in Zambia



Source: Kai Sonder, CIMMYT-SEP

CIMMYT

WB in Bangladesh

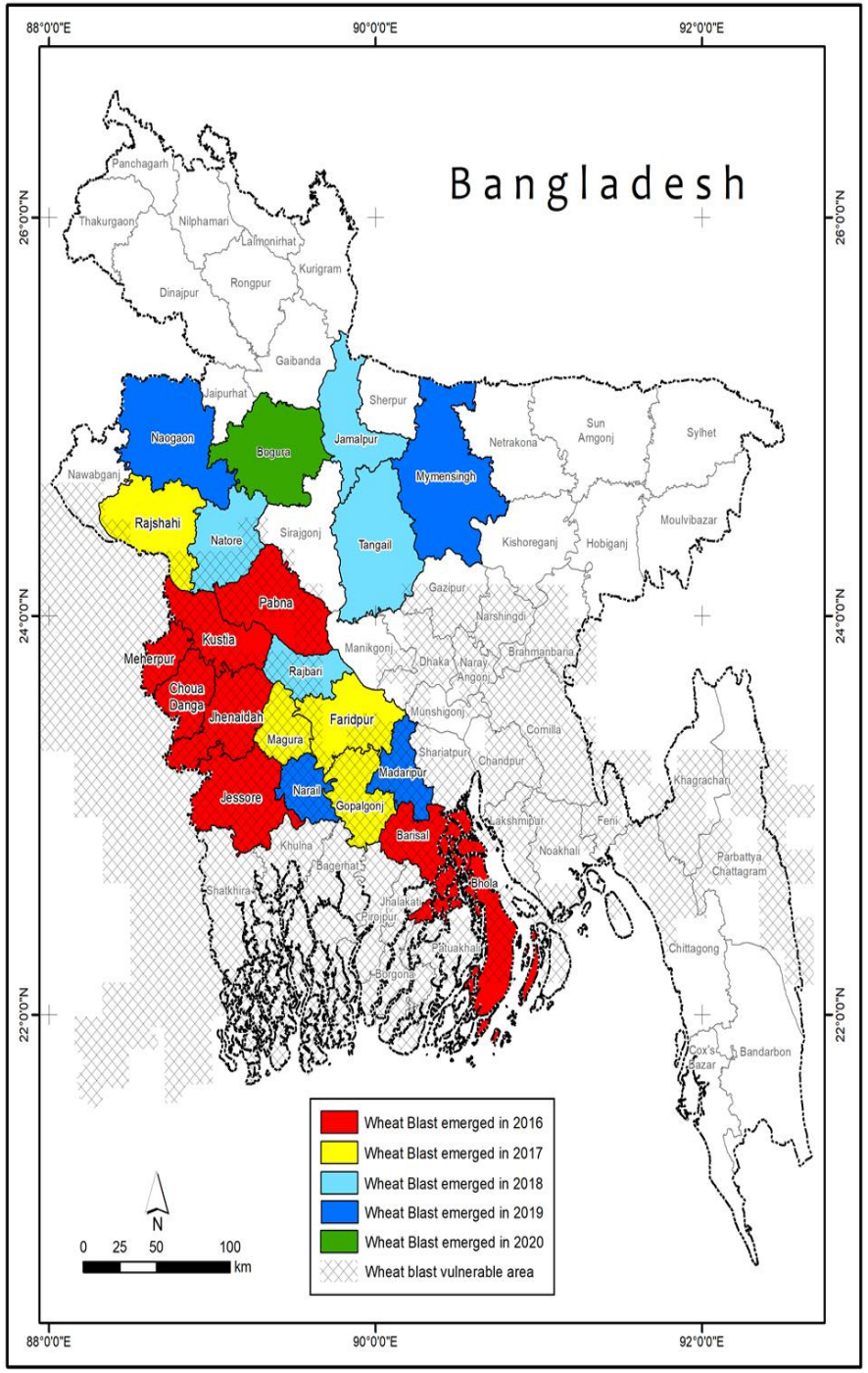
2015-16: 1st report of WB occurrence in **eight** districts. 25-30% loss

2016-17: WB spread to **four** more districts. 5-10% loss

2017-18: Unfavorable conditions for development of WB. Spread to additional **five** districts. 3-5% loss

2018-19: WB limited due to unfavorable conditions. Spread to **four** more districts. 1-2% loss

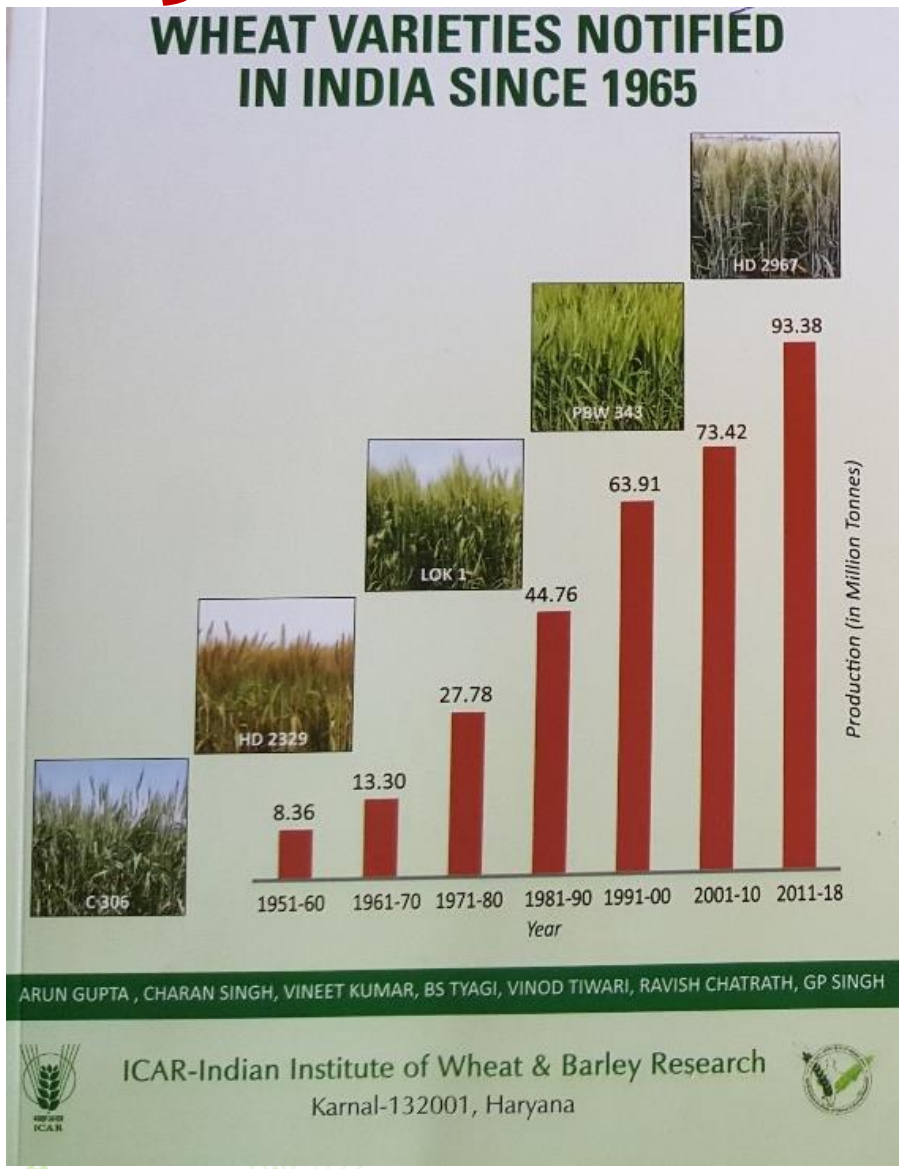
2019-20: WB limited due to unfavorable conditions. Spread to **one** more districts. 1-2% loss



MYT MR

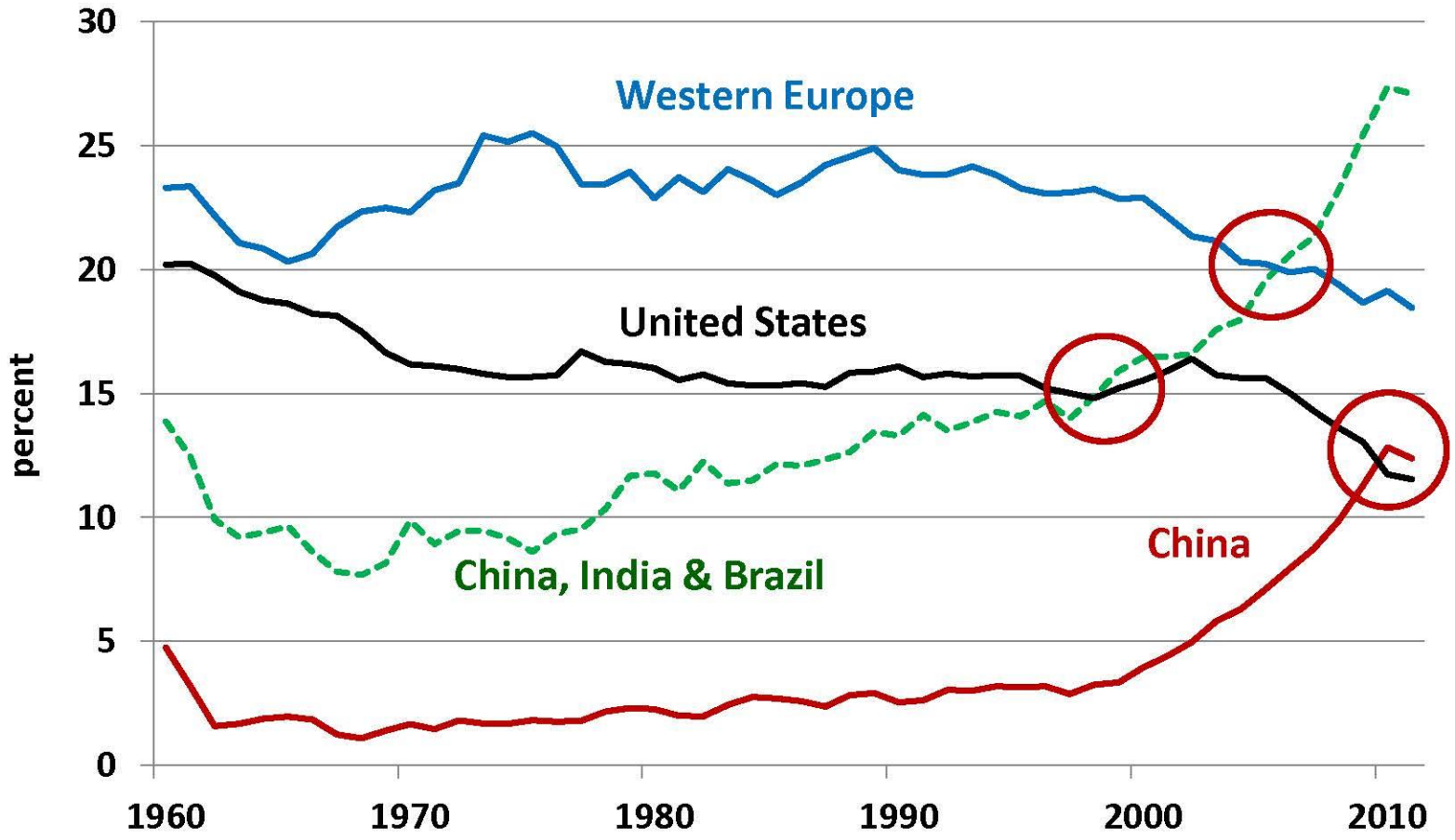
Wheat breeding in India 2013-2018

- >50 CIMMYT derived wheat varieties released
  22 direct CIMMYT introduction
  30 derived from crosses between Indian and CIMMYT parents
- 4 biofortified (high Zn) wheat varieties released (2 public, 1 private, 1 PVS)
- ~35 centers got new germplasm (~600 lines) each year
- Indian germplasm tested for Ug99 (in Kenya) and wheat blast (in Bolivia and USA)
- >300 scientists attended international events and training courses
- 6 of 8 released varieties in 2019 CIMMYT derived



CIMMYT

Shifting Global Shares of Public Food & Ag R&D, 1960-2011



Source: Pardey, Chan-Kang, Beddow and Dehmer (2016, in process)

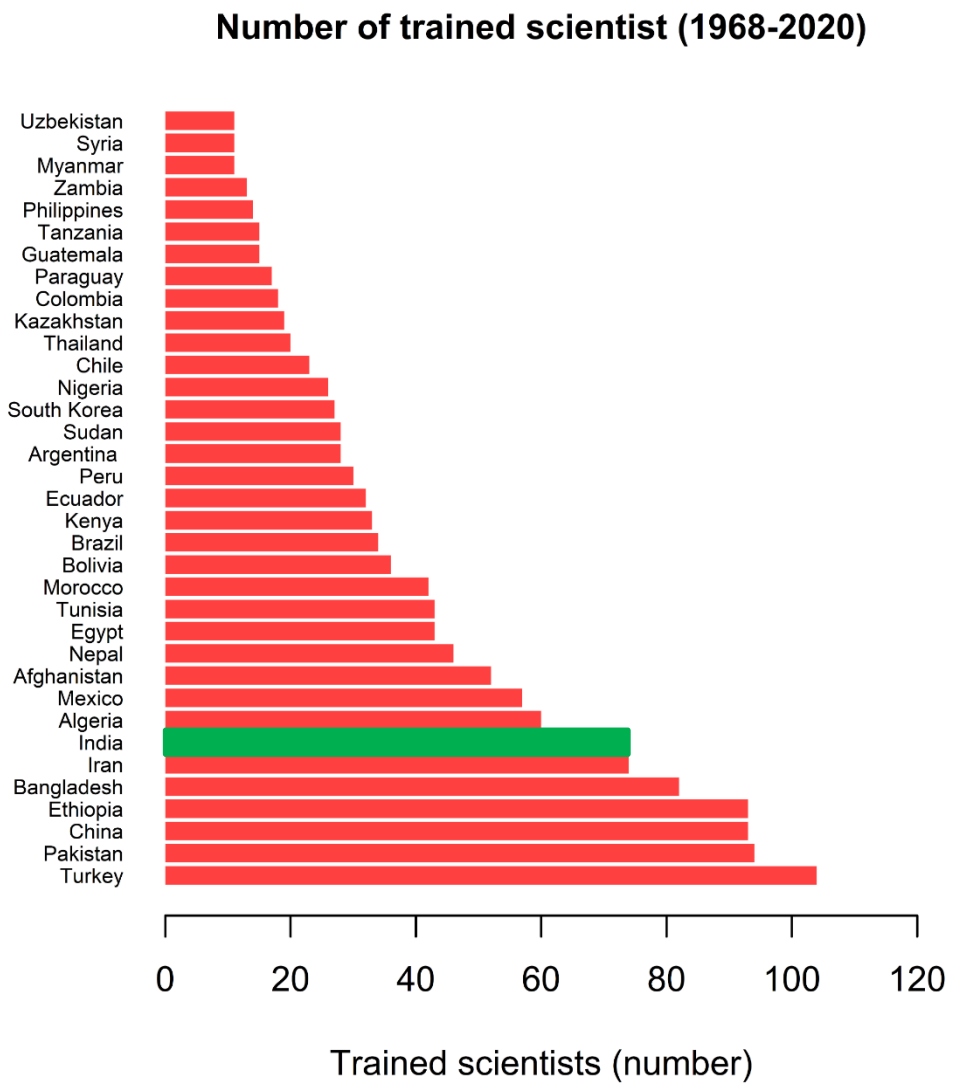
MYT MR

1600 wheat scientists from >90 countries have been trained at CIMMYT

Many visiting scientists

10 International Recruited Indian Scientists

Program Director Dr. S. Rajaram
Breeding Lead Dr. R. Singh



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Conclusion

IS/ISO 9001 : 2008 Organization
ICAR Reporter
ISSN No.: 2394-3254
www.icar.org.in
APRIL – JUNE 2018

The partnership between ICAR and CIMMYT in agricultural research is one of the longest and most productive in the world with a history of over five decades. The collaboration started with the visit of Nobel laureate Dr Norman E. Borlaug to India in 1963 for help in paving the way for "Green Revolution" in active partnership with the national agricultural research system (NARS), farmers and the Government of India.

CIMMYT germplasm goes to the right place in South Asia – to farmers, scientists, students, industry and other stakeholders

CIMMYT

Conclusion

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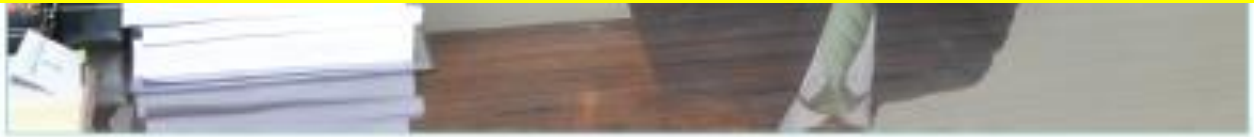
The partnership between ICAR and CIMMYT in agricultural

Whatever matters for wheat in India,
Matters for CIMMYT's Global Wheat Program

To the next decade of a
Fruitful and Productive co-operation



help in paving the way for "Green Revolution" in active partnership with the national agricultural research system (NARS), farmers and the Government of India.

CIMMYT


Thank You very much for your attention