

Farmers and consumers' choice of biofortified wheat in South Asia

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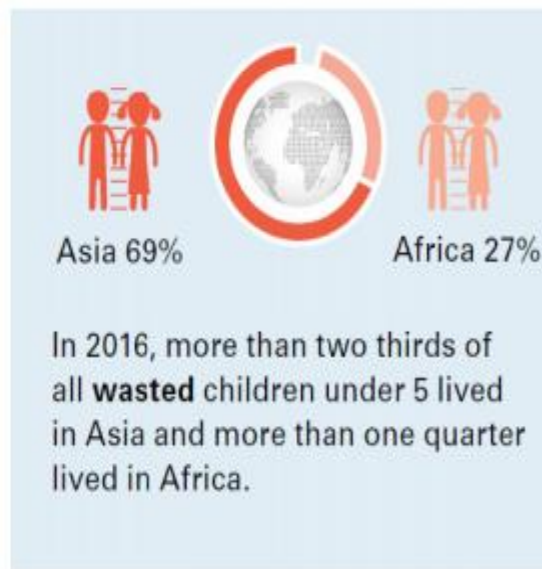
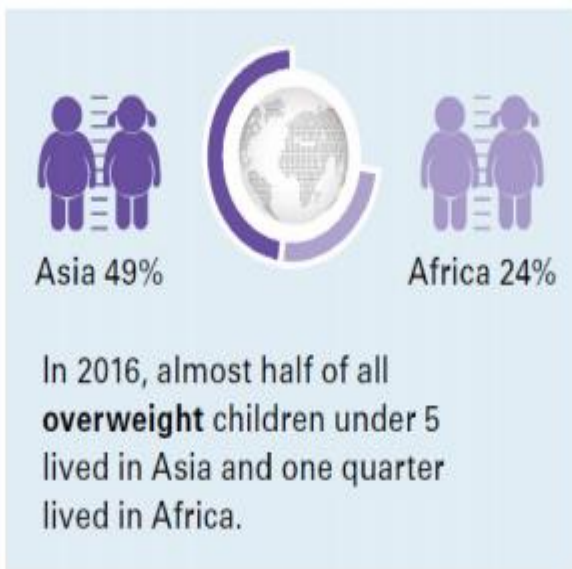
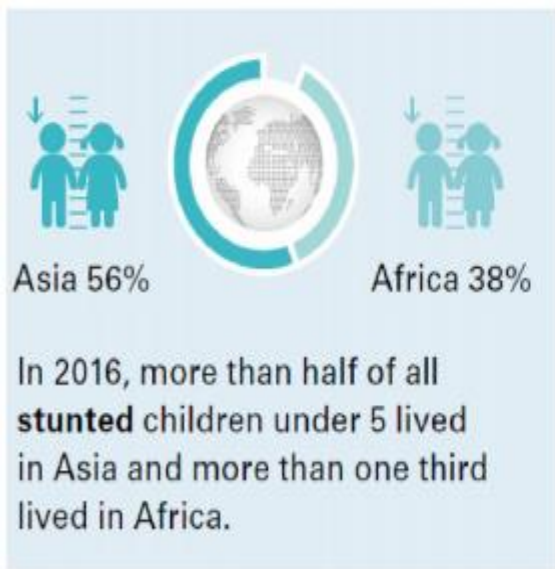
1. Global Wheat Program, CIMMYT

2. HarvestPlus, CIAT/IFPRI

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Malnutrition: Global status

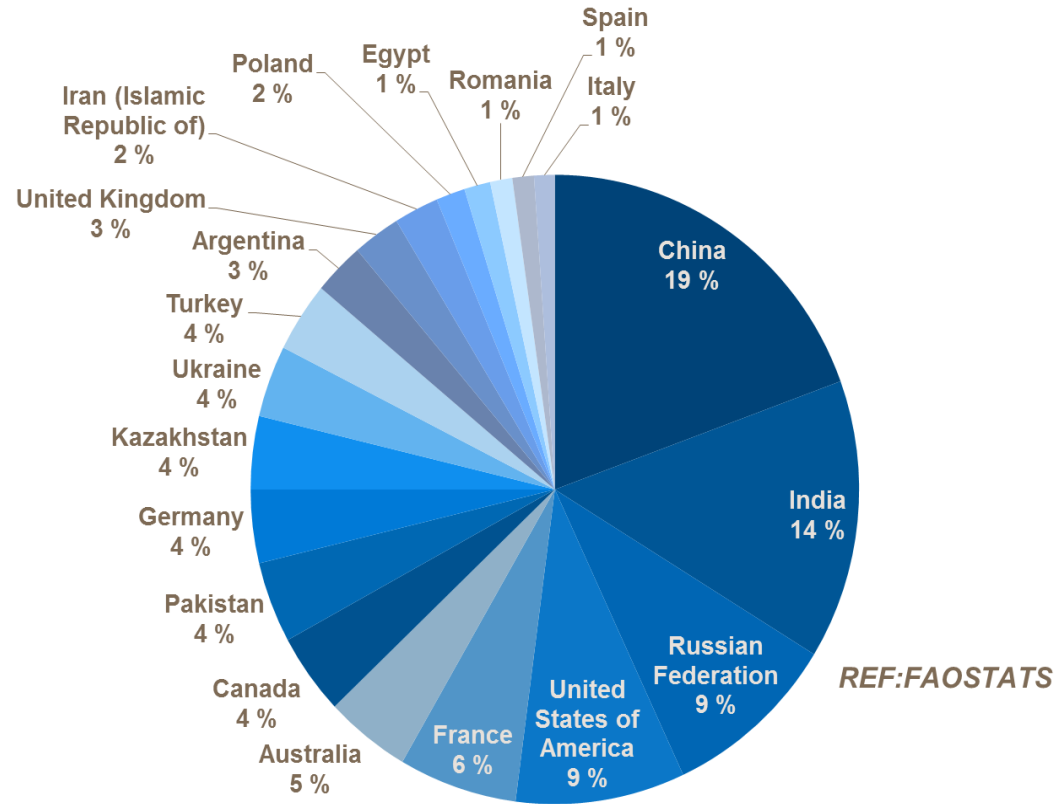
- **2 billion** malnourished people worldwide
- **>155 million** children (below 5 age) are stunted & lower BMI
- Malnutrition contributes to **>10% GDP loss** in Asia and Africa



WHO/UNICEF report 2017



*Wheat production
needs to increase by
60% to feed 9.6 billion
people in 2050.*



**Population growth, rising incomes and
changing diets – demands more
nutritious food**

Wheat Breeding Priorities

Core traits

- High and stable yield potential
- Durable resistance to Rusts- Stem (Ug99), Stripe and Leaf
- Water use efficiency/Drought tolerance
- Heat tolerance
- Appropriate end-use quality
- *Enhanced Zn and Fe content for nutrition (currently South Asia, mainstreaming plans underway)*

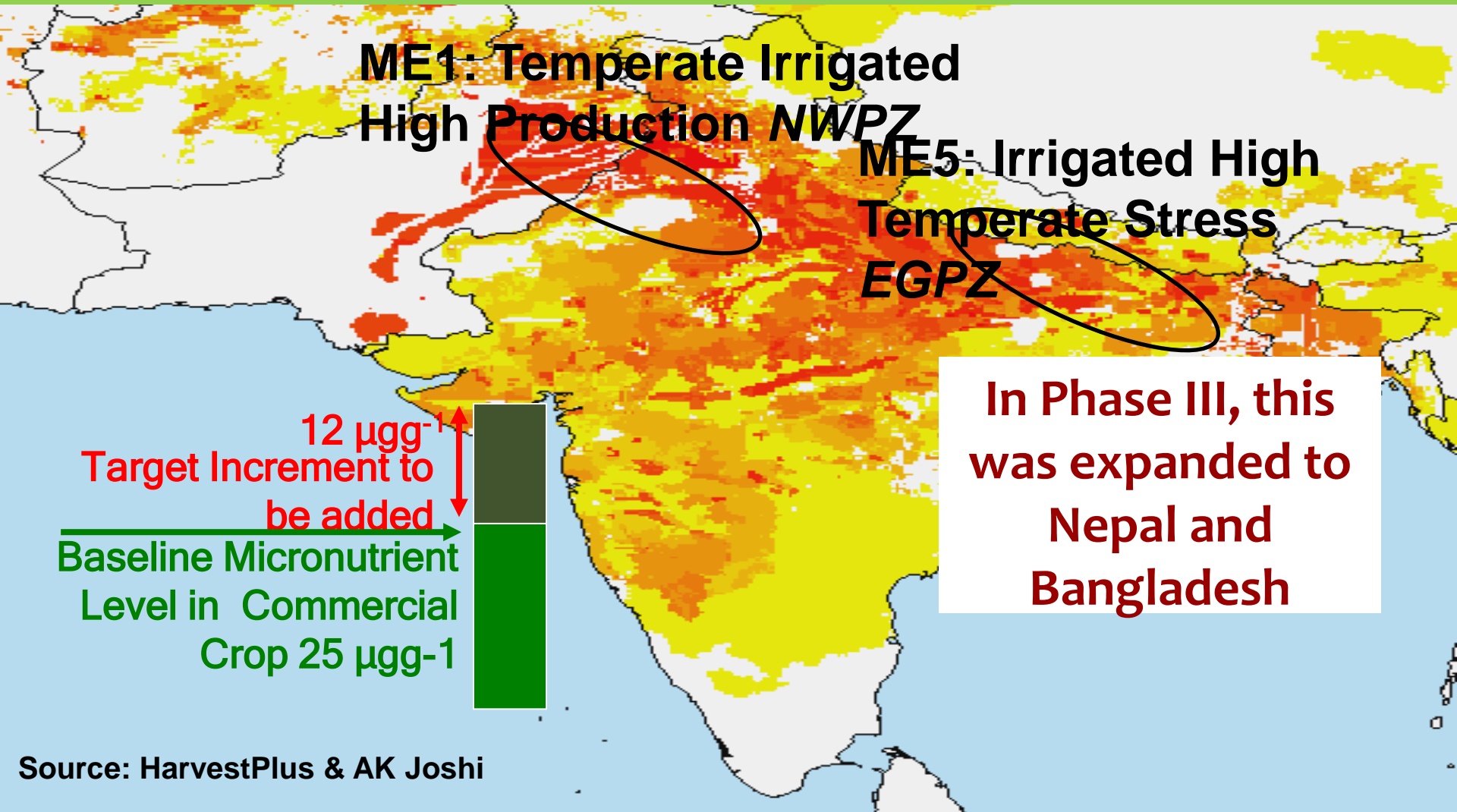
Key diseases in specific mega-environments

- Durable resistance to diseases and pests
 - ◆ Septoria leaf blight (ME2)
 - ◆ Spot Blotch (ME5)
 - ◆ Tan Spot (ME4)
 - ◆ Fusarium – head scab and myco-toxins (ME2/4/5)
 - ◆ Karnal bunt (ME1)
 - ◆ Root rots and nematodes (ME4)
- *Wheat blast- new threat in South Asia (ME5)*

Packaging multiple traits together is essential under climate change scenario to benefit wheat farmers



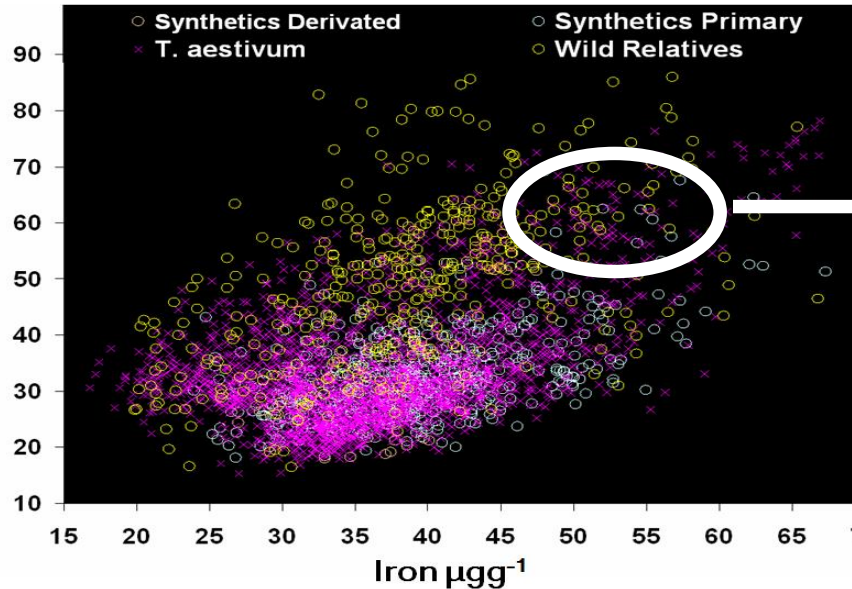
Initial Target Countries / Areas for Zinc Wheat



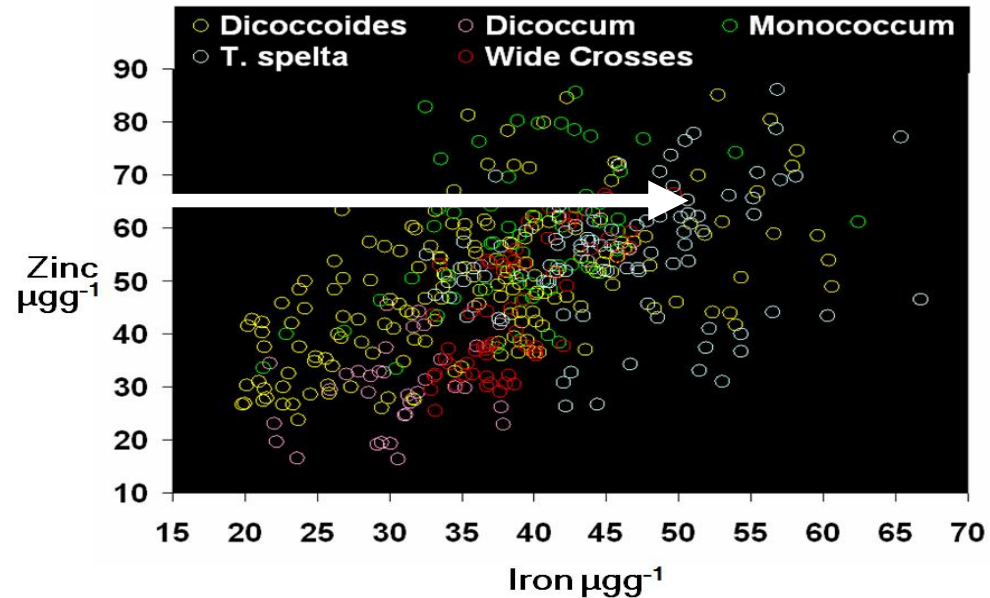
Genetic Variation

- Variation for micronutrients to surpass the target in wild relative species / unadapted germplasm
- Lack of genetic variation in adapted, high yielding genotypes

Genetic Variation for Zinc & Iron in Wheat



Wheat Wild Relative Species



Shuttle Breeding: Key to CIMMYT's widely adapted germplasm

Winter Cycle:

Obregón

(28°N, 38 masl)

November - May.

Diseases: Leaf

Rust, Karnal bunt



* Initial period after sowing

Summer Cycle:

Toluca/El Batán

(18.5°N, 2600 masl)

May - October.



- Annually >400 simple and 300 top-crosses, early generation selection for agronomic traits (F1Top to F4)
- selection for Zn and agronomic traits (>10,000 F5 & F6 small plots with repeated checks)
- 1st year yield trials (1,500 lines) = selection for yield and Zn (F6 & F7)
- 2nd year multi-env. yield trials (150 lines) = zinc and yield stability

HPAN and HPYT distribution to partners

From genetic resources to High zinc wheat in farmers' fields of South Asia in less than 10 years

Progenitors:



= **Zn-Shakti' PVS variety:** Extra-early with +14 ppm Zn (40% increase) adopted by >40000 farmers in NEPZ
CROC1/AE.SQUARROSA(210)//
INQALAB 91*2/KUKUNA/3/
PBW343*2/KUKUNA



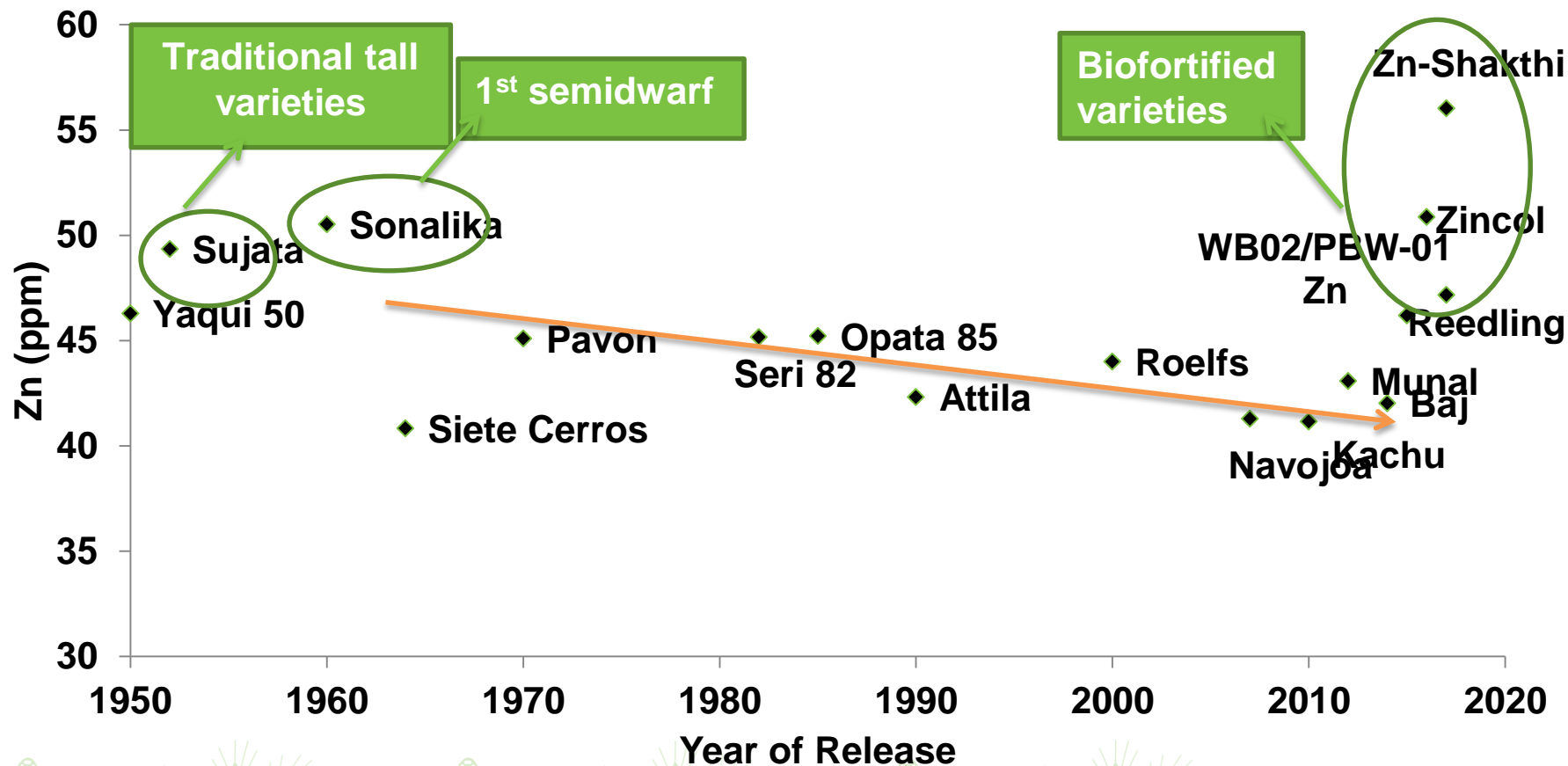
= **Zincol 2016:** 1st high zinc wheat in Pakistan with +6 ppm Zn = 2000 tons of seed to be sown in 2016-17
OASIS/KAUZ//4*BCN/3/2*PASTOR/
4/T.SPELTA PI348449/5/BACEU
#1/6/WBLL1*2/CHAPIO



T.DICOCCONCI9309/AE.SQUARROSA
(409)//MUTUS/3/2*MUTUS =
WB02/HPPW-01/Ankur Shiva
Three sister lines (+6 ppm Zn) released for NWPZ of India



Zn levels in historic and modern wheats vs biofortified wheat



First biofortified blast resistant variety released in Bangladesh (Bari Gom 33)

- **Kachu/Solala**
- **2NS segment for blast resistance**
- **+ 7 ppm Zn advantage**
- **Bold grain size**



Meeting stakeholders demands in value chain

Farmers	Crop performance and resilience <ul style="list-style-type: none">• Yield and abiotic stresses: heat and drought etc.• Pest and disease resistance• Agronomic and harvesting characters• Performance with low inputs• Genetic diversity and climate change	Consumers	Quality characteristics <ul style="list-style-type: none">• Taste• Colour• Appeal• Nutritional value• Cooking qualities• Storage
Seed producers	Seed Production <p>Fertility and scalability Cost of seed production Lodging tolerance and non-shattering traits</p>	Processors	Processing traits <ul style="list-style-type: none">• Performance and suitability for processing• Cost variables• Storage

Farmer participatory selection: STRIP trials and on-farm & station trials

3 hectare field of BHU-35 (KACHU/SOLALA)

Farmer: Harbansh Singh, Pidkhir, Mirza,

HarvestPlus Participatory
Varietal Selection (**HPVS**)
started in **2005**

14 superior entries identified
with high zinc and high yield till
2015-16

STRIP trials composed of
leads identified by
public & private partners

STRIP trials planted at **22**
locations of **3 district** of India in
2016-17 & 2017-18

Mirzapur
district

Varanasi
district

Chandauli
district

PVS: farmers' preference for agronomic traits in Bangladesh (BARI-Gom 33)

Genotypes	Farmers' preference at Physiological maturity stage							Farmers' preference at post harvest stage						
	Plant height	Tillering habit	Spike length	Disease incidence	Maturity	Expected yield	Overall Score	Grain color	Grain size	Grain weight	Black point	Yield basis	Overall score	Yield (t/ha)
Shatabdi	7.1	8.5	7.8	8.2	6.8	7.8	7.6	7.4	7.4	7.3	8.1	7.2	7.6	3.93
BARI Gom 28	9.1	8.4	7.8	8.1	8.8	8.8	8.3	7.9	7.5	7.6	7.6	8.2	8.1	3.94
BAW 1203	8.6	8.4	7.3	8.1	8.2	8.7	8.4	8	7.8	8.4	8.3	8.4	9.0	4.21
BAW 1208	7.8	8.3	8.2	8.0	7.7	8.6	8.1	8.7	8.4	8.5	7.9	8.3	8.3	4.06
BAW 1222	8.3	7.8	7.9	7.9	9.0	8.0	8.3	8.5	8.4	7.9	8.3	8.4	8.6	4.03
BAW 1243	7.9	8.2	8.0	7.9	8.3	8.0	7.9	8.1	8.2	7.9	8.1	8	8.3	3.98
BAW 1254	7.6	8.1	8.2	7.8	8.1	8.4	8.3	8.4	8.2	8.3	8.8	8.3	8.2	3.99
BAW 1260	7.8	7.6	9.1	8.1	8.8	8.8	8.5	7.5	8.4	8.3	7.2	8.0	8.9	4.09
F-test	**	NS	*	NS	**	NS	NS	**	NS	*	NS	**	NS	*
LSD (0.05)	1.09	-	0.87	-	0.72	-	-	1.51	-	1.28	-	1.91	-	0.0104
CV (%)	6.7	9.5	10.6	12.7	8.7	9.3	9.6	6.7	9.5	10.6	12.7	8.7	9.3	9.6



PVS activities at Banaras Hindu University



Shortening Time-to-Market

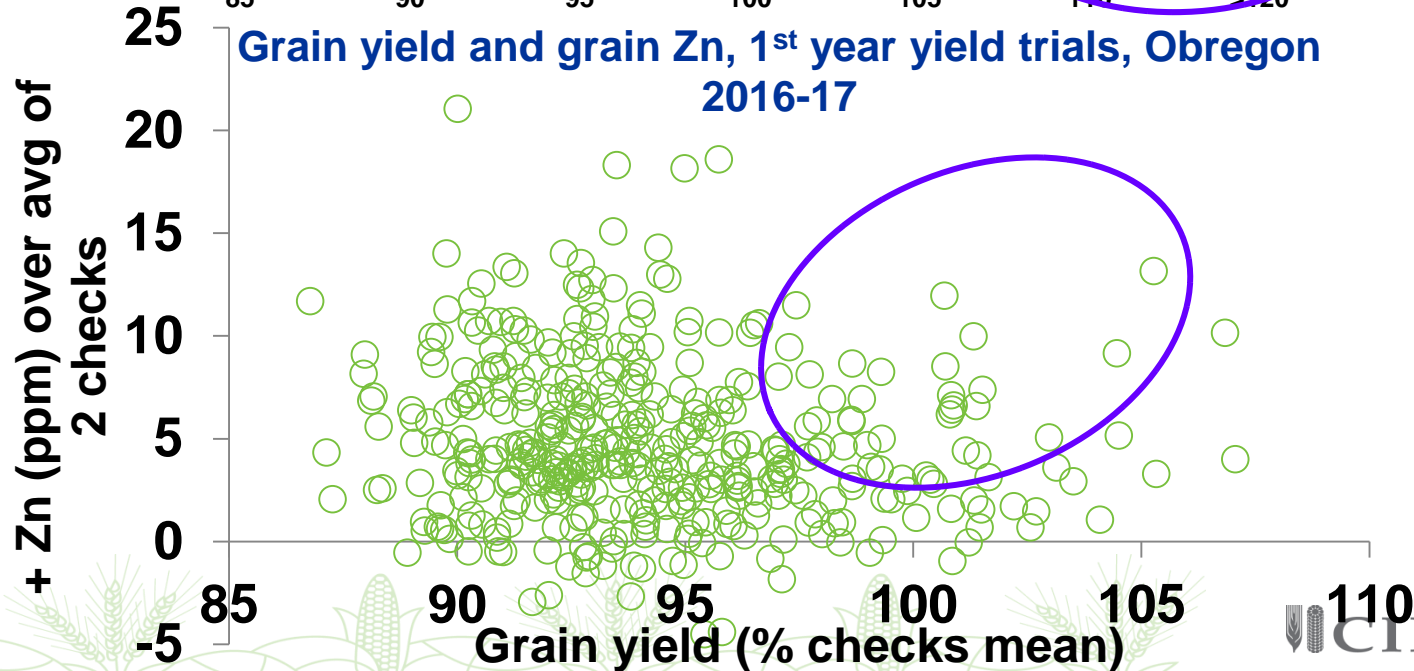
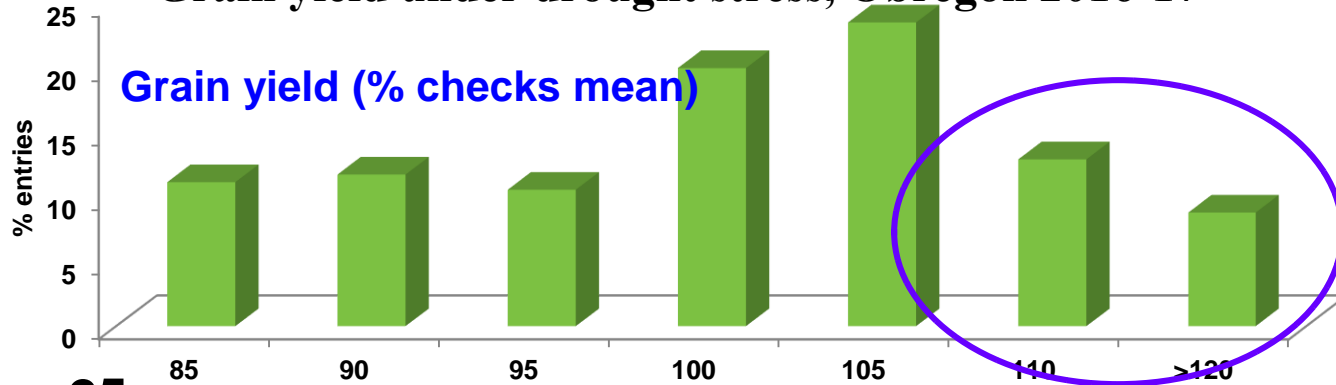
Off-season initial seed production to shorten time to market and provide top quality seed



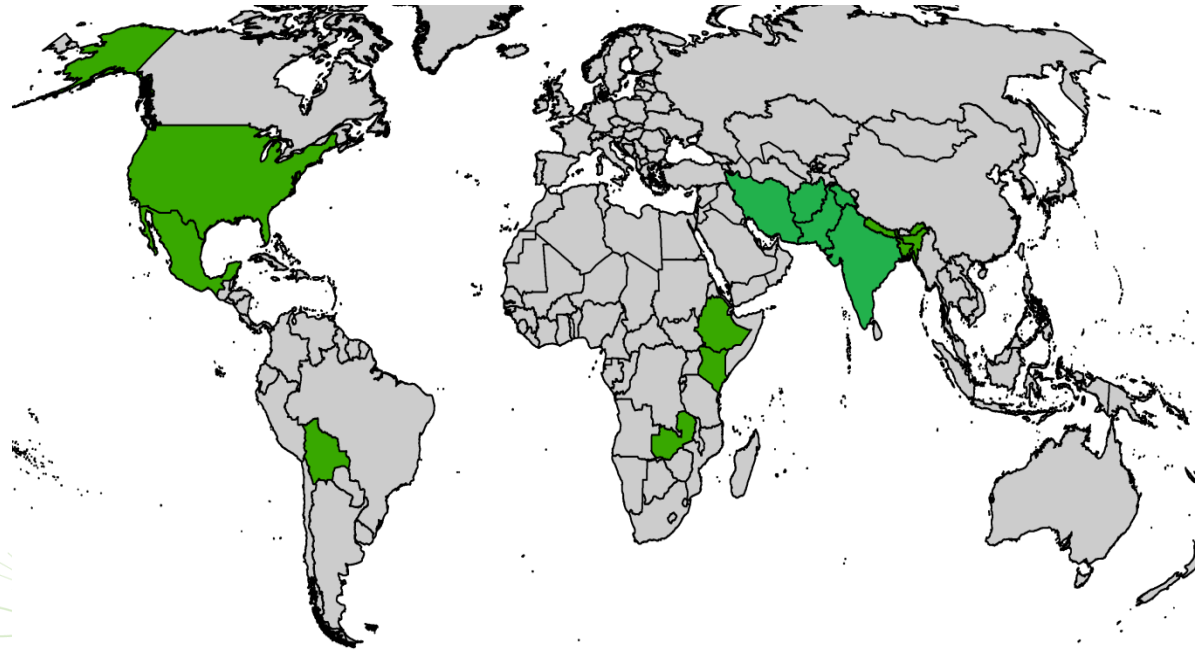
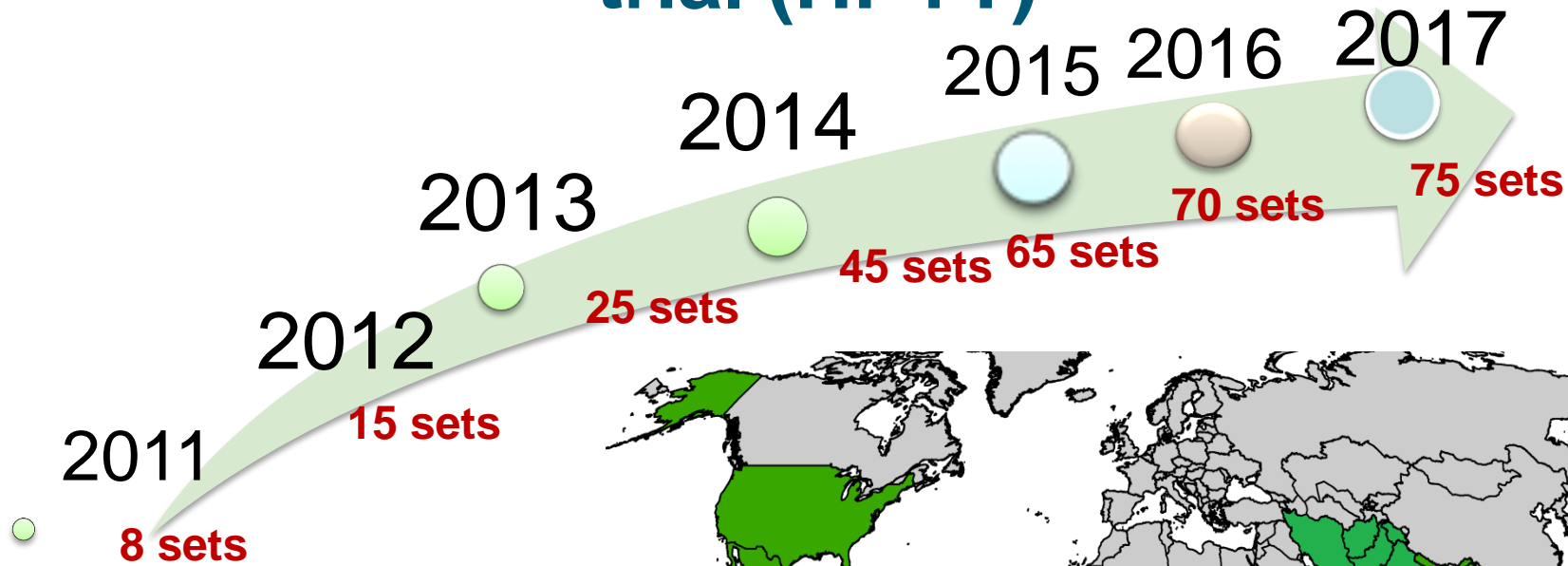
Source: WH Pfeiffer

Grain zinc can be mainstreamed

Grain yield under drought stress, Obregon 2016-17

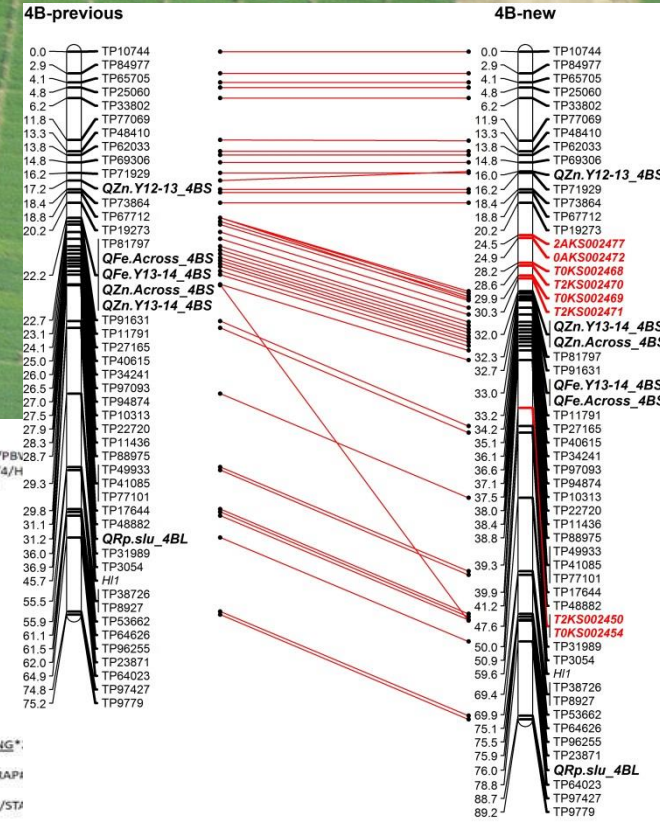
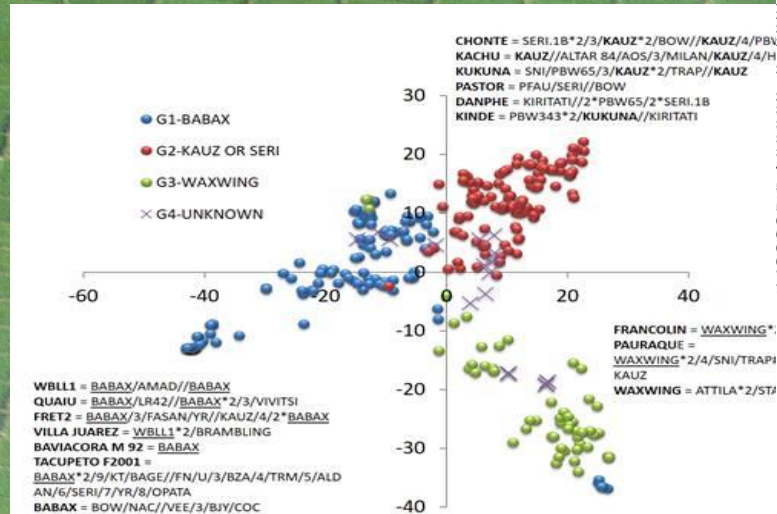


Increasing demand for Zinc-rich wheat trial (HPYT)



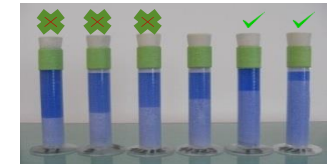
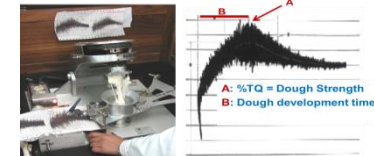
Genomic regions from diverse origins mapped

- HPAM panel of 320 advanced lines
- Panel derived from 29 diverse progenitors & 90k Illumina SNP markers



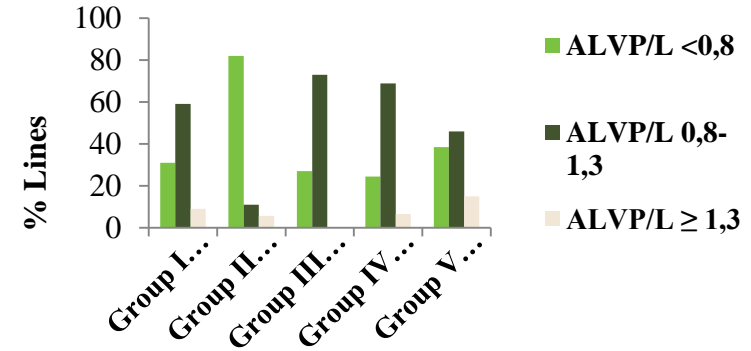
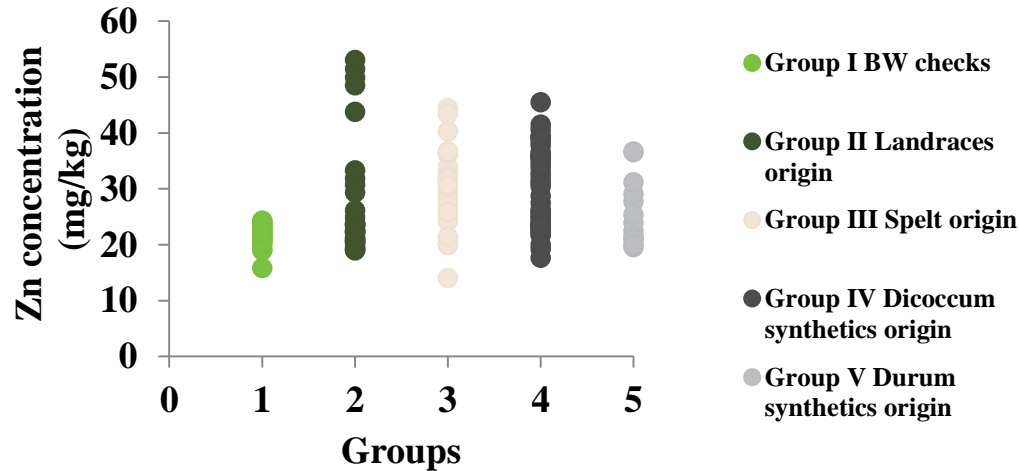
Wheat Quality Testing –Meeting consumers demand

- Grain characteristics: density (test weight), size (kernel weight) and color. **Image analysis**.
- Grain properties: hardness and protein content. **Near-infrared Spectroscopy (NIRS)**.
- Milling properties: flour yield and ash content. **Brabender Quadrumat Senior mill**.
- Flour properties: protein content and water absorption. **NIRS**.
- Gluten quality: overall gluten quality, optimum mixing time, gluten strength and extensibility. **SDS-Sedimentation, mixograph and alveograph**.
- Bread-making quality: loaf volume and crumb structure quality and color.
- Micronutrients: **XRF and ICP analysis**



Wheat Biofortification. Processing and end-use quality

Screening of micronutrient-enhanced wheat germplasm. HPAN and HPYT candidate lines



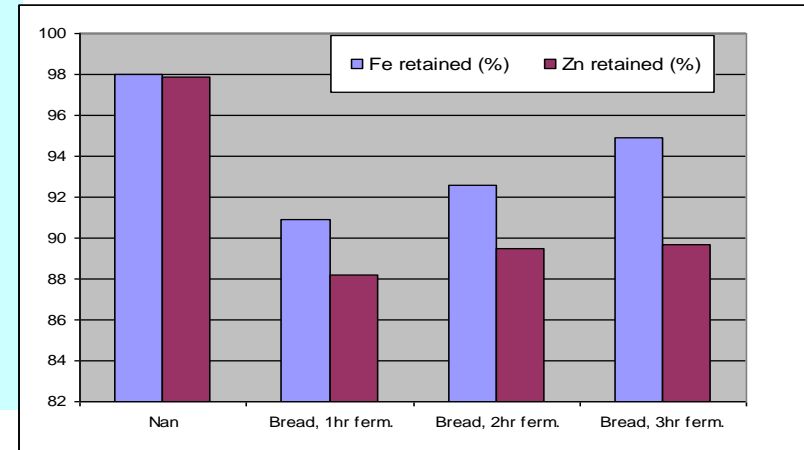
Guzman et al. 2014

Large proportion of lines showed desirable quality traits:

- Medium hard to hard grain
- Medium to high Sedimentation volume
- Medium to strong gluten type (Mixing time Mixographic type).

Effect of processing on micronutrient bioavailability (Fe, Zn). Fe & Zn Retention in wheat, flour and food products

- The 80%-extraction flour retains 50-60% of Fe and Zn present in the grain
- The flat bread Nan retains most Fe and Zn present in the refined flour.
- Leavened bread contains ~90% of the Fe & Zn present in the same weight of flour.



Fe and Zn concentration increases with fermentation time in leavened breads.

Enzymatic degradation of phytic acid requires an optimum pH & degradation of phytic acid can increase the amount of soluble iron, zinc and calcium several folds (Haard et al. 1989)

Source: Ivan Monasterio and Javier Pena

Consumer satisfaction



BHU-3

BHU-31



Spontaneous Likes for Atta (commercial vs biofortified Zn flour)

All Figs in % except base

Base: All Respondents

	Unaided Panel		Aided Panel	
	Normal atta	Zn Bio Atta	Normal atta	Zn Bio Atta
	235	235	234	234
Appearance & texture of chappati /atta	85	87	83	85
Soft chapatti	75	77	72	74
Good color of the Chapatti	13	18	6	11
Good color of the atta	7	11	16	19
Flour is Soft	2	2	3	5
Chappati is tasty	58	62	64	71
Flavour/aroma of chappati /atta	16	23	20	20
Chappati has good aroma	15	19	6	6
Liked the flavour of the atta	1	5	14	15
Preparation related Likes	4	7	4	8
Good to make dough	3	3	3	5
Easy to make dough	1	3	1	3
It is good to eat	5	9	3	3

- Consumers who were informed about Zinc Bio-fortified atta, found chapattis from Zinc Bio-fortified atta to be more tastier than those who were given atta at blind level.
- However, among both set of users, zinc bio fortified atta scores directionally higher than that the normal atta.

POSHAN Abhiyaan

PM's Overarching
Scheme for Holistic
Nourishment

सही पोषण

March 08, 2018



Reduce stunting, under-nutrition, low birth weight and anaemia below 25% by 2022 in India.

Conclusion

- **Continuous progress in genetic enhancement**
- **Varieties released in 3 countries of South Asia; more to come**
- **Largescale seed dissemination underway**
- **Genomic regions from diverse origins mapped-hotspot candidate regions identified**
- **Pyramiding/accumulating additive effect QTLs from diverse sources into elite wheat lines.**
- **Mainstreaming of Zn in CIMMYT wheat breeding**
- **Maintaining appropriate end-use quality is important**

Acknowledgements



WH Pfeiffer
P. Virk
M.S. Andersson



GP Singh
Ravish Chatrath



VK Mishra
Ramesh
Chand



VS Sohu
NS Bains
GS Mavi



Anju
Mahendru



Yaqub Mujahid
Atiq Rattu,



ND Barma
Farhad



James
Stangoulis
Georgia





Thank you
for your
interest!