Crop Genetic Diversity for Climate Resilient Agriculture

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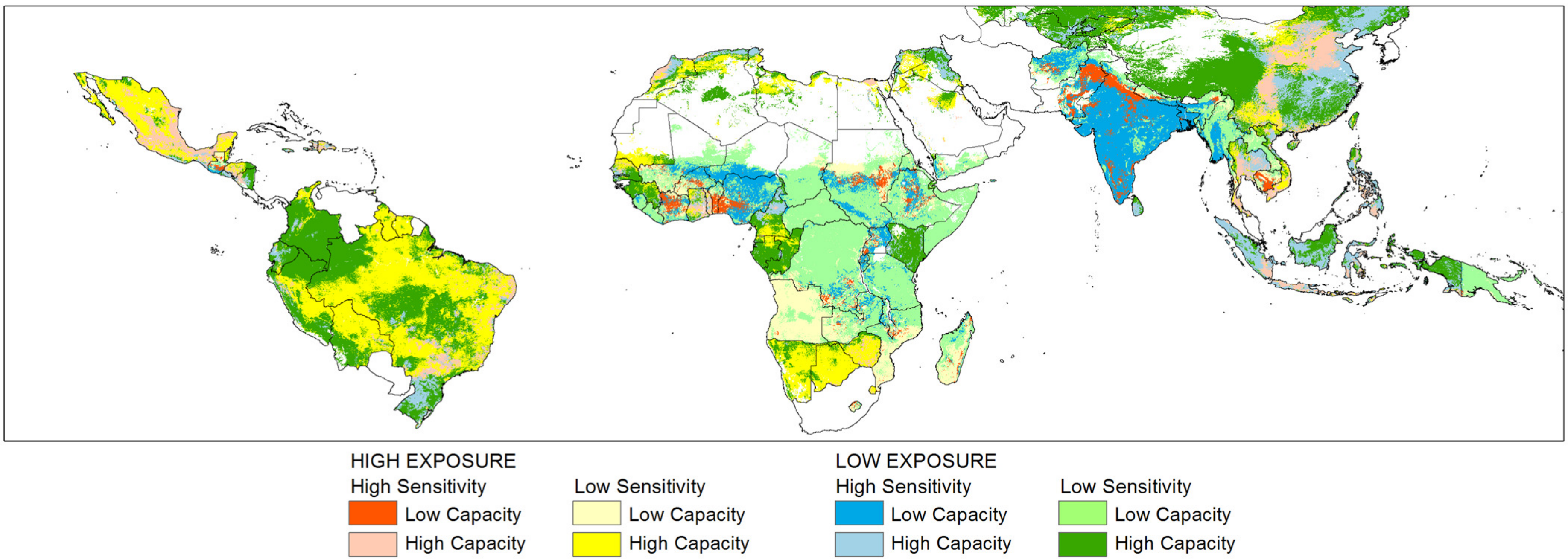
Challenges facing Agriculture

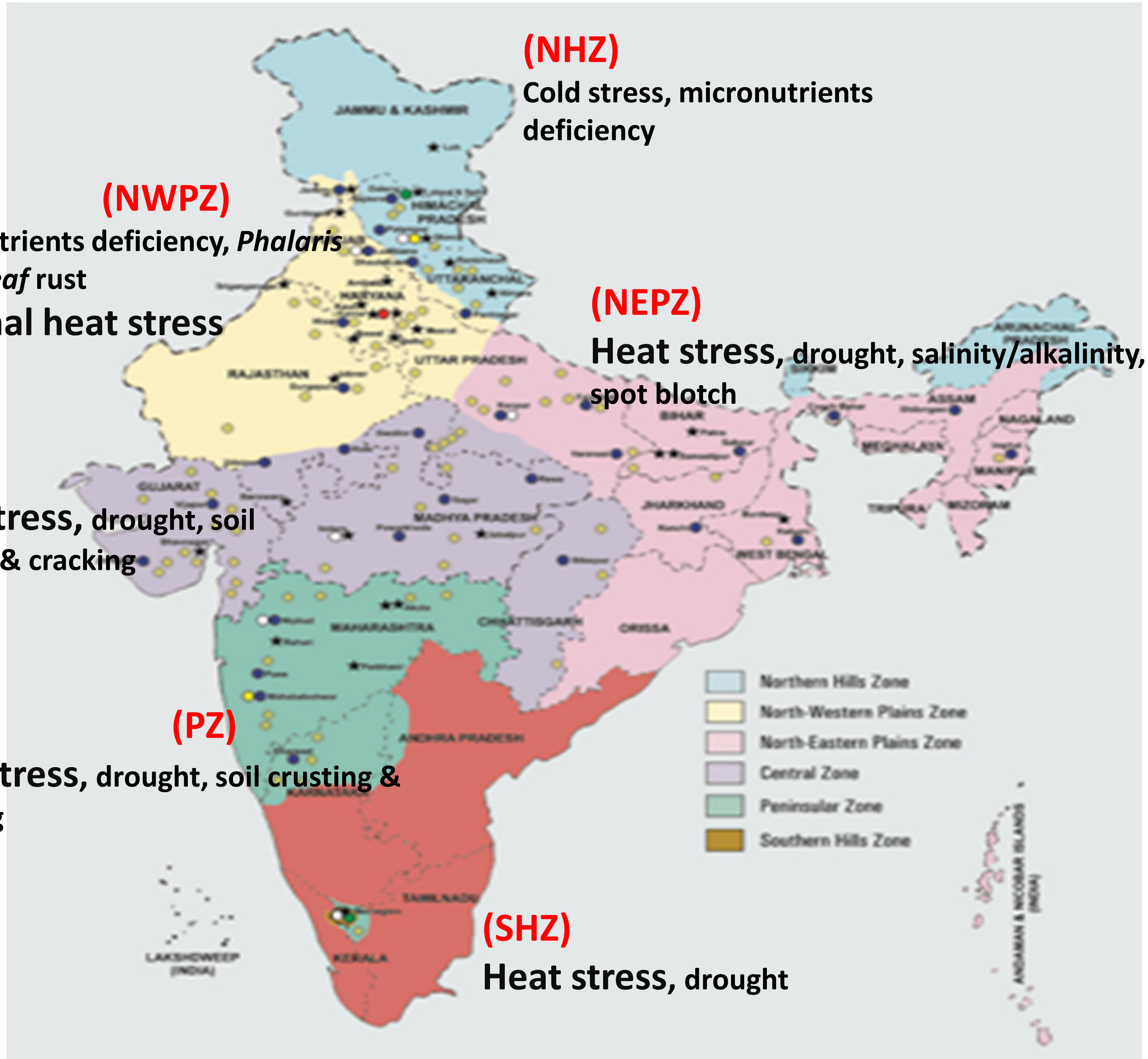
- **Climate change**
- Shrinking availability of natural resources
  - Land
  - Water
- Biotic and Abiotic Stress factors
- Malnutrition
- Sustainability in Agricultural production

Most climate change studies project significant decrease in crop yields in South Asia



(Source: Erickson et al., 2011)

Wheat growing zones of India and constraints in wheat production



(NHZ)

Cold stress, micronutrients deficiency

(NWPZ)

Micronutrients deficiency, *Phalaris minor, leaf* rust

Terminal heat stress

(NEPZ)

Heat stress, drought, salinity/alkalinity, spot blotch

(CZ)

Heat stress, drought, soil crusting & cracking

(PZ)

Heat stress, drought, soil crusting & cracking

(SHZ)

Heat stress, drought

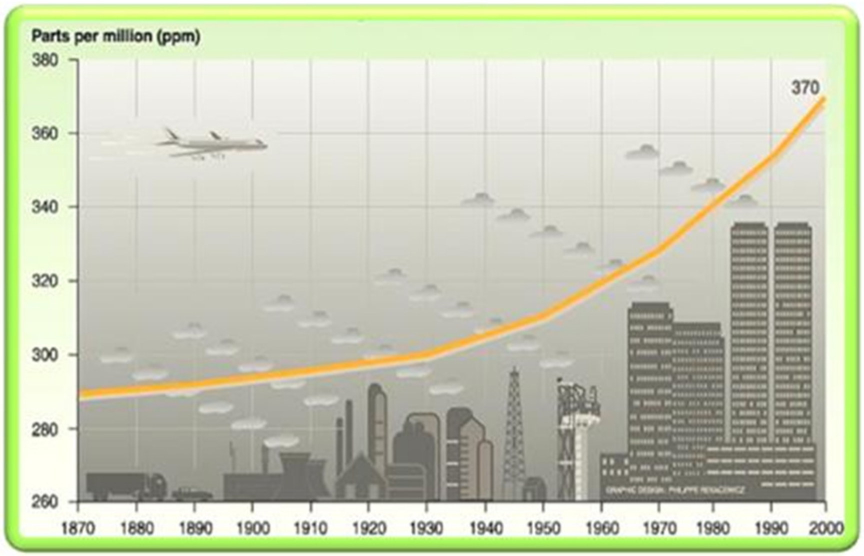
Climate change impact on wheat

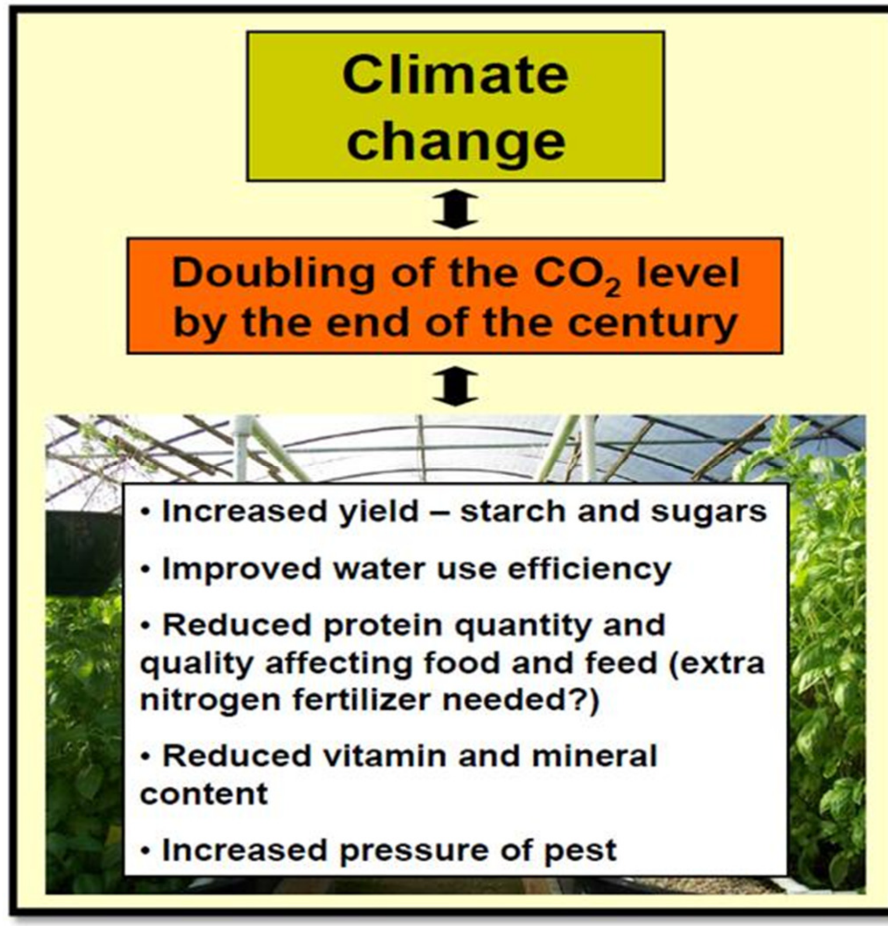
- Increase in 1-3^{0}C temperature may reduce yield up to 10% by 2020 in Asia (IPCC)
  - 5-7 % decline in wheat yield for every degree increase in temperature
- Adaptation and mitigation strategy
  - Development of heat tolerant varieties
  - Changes in crop management practices, including use of water saving technologies
  - Weather forecasting and risk management measures

Major constraints for wheat productivity enhancement in India

- **Heat stress**
- **Shrinking water and land resources**
- **Breeding constraints**
    - Lack of screening and phenotyping methodologies
    - Lack of pre-breeding efforts
    - **Narrow genetic base**

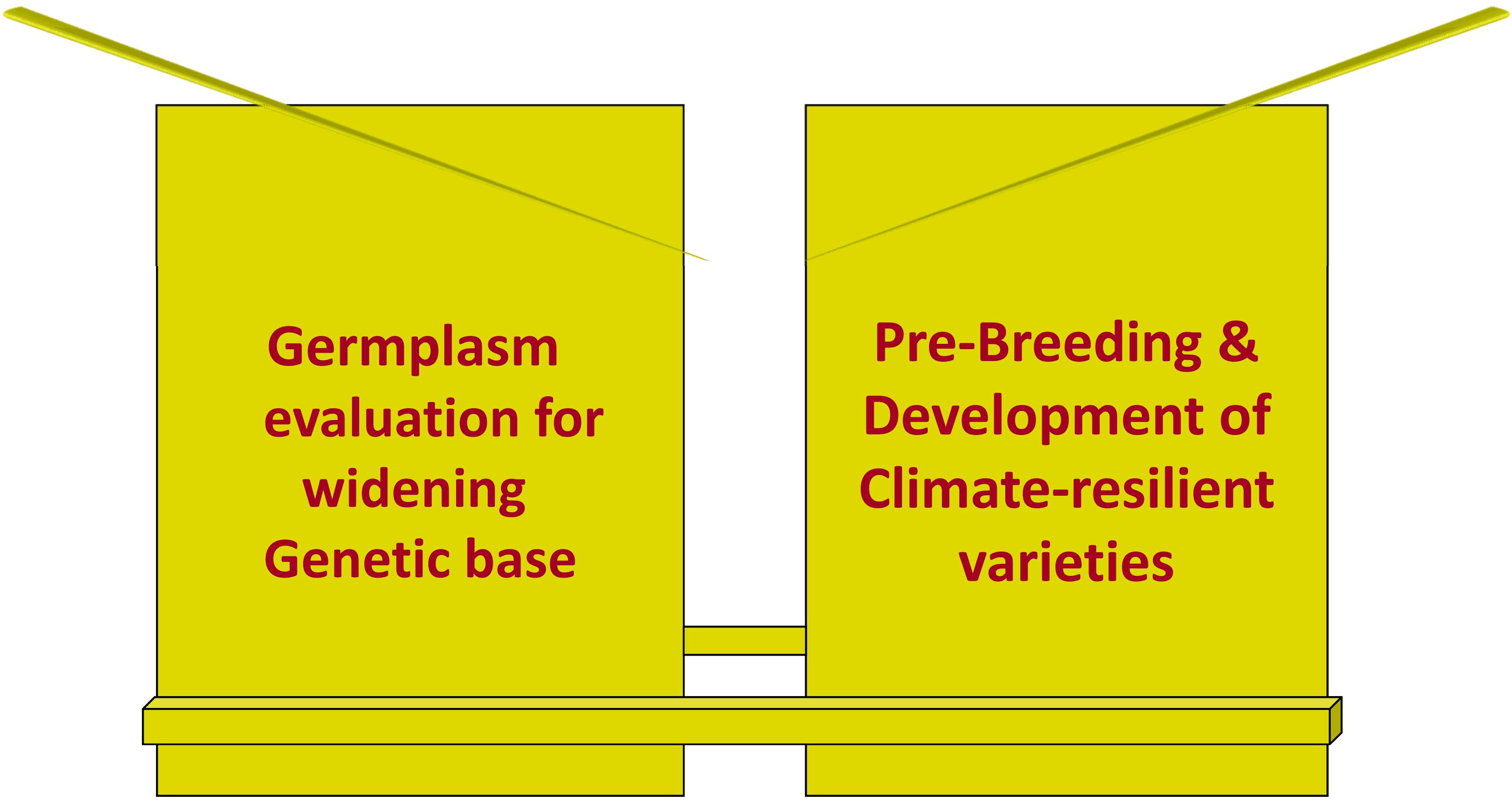
Effect of Enhanced CO_2





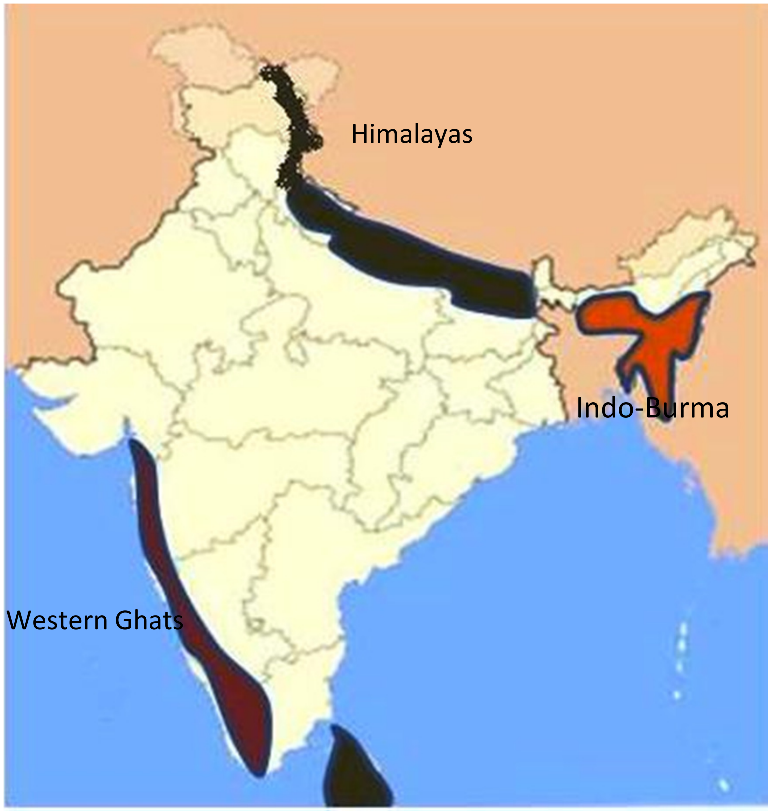
Change in insect-pest dynamics

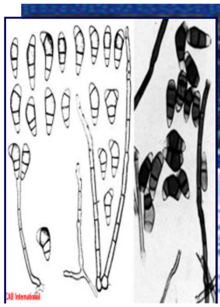
Twin Pillar Strategy

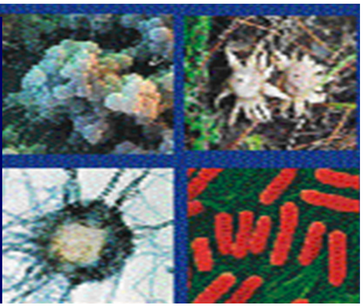


India - A gene rich region

- One of 12 world mega biodiversity centres, 17 mega diversity nations
- Three of the 34 Hot Spots of Biodiversity
  - Himalayas, Indo-Burma region, Western Ghats & Srilanka
- Western Ghats, the hottest spot with 68% endemic freshwater fish species
- 162 breeds of domesticated animals
- 10% of world's microbes, 6% of insects, 12% of birds and 20% of lower plants







PGR Conservation at National Genebank NBPGR, New Delhi, India

Crop Group	Present status*
Cereals	1,50,173
Millets and Forages	55,171
Pseudo cereals	6,657
Grain legumes	57,243
Oilseeds	55,803
Fiber Crops	11,535
Vegetables	24,377
Fruits	530
M & A P & Narcotics	6,404
Spices & Condiments	2,894
Agro-Forestry	2,442
Safety Duplicate	10,235
Grand Total	**3,97,829**

*The figure includes 3777 released varieties and 2024 Genetic stocks

Goal

Enhanced Agricultural Production

by

Enhanced Utilization of PGR

Prioritization Matrix

Trait / Crop	Biotic stress	Abiotic stress	Nutritional quality	Earliness /Photo- and thermo insensitivity
Rice	***	***	**	*
Wheat	***	***	**	**
Maize	*	**	***	--
Finger millet	*	*	***	**
Pearl millet	*	***	--	--
Sorghum	***	**	--	--
Chickpea	***	**	*	--
Pigeonpea	***	**	--	**
Rapeseed mustard	***	**	**	--
Brinjal	***	*	--	--
Okra	***	--	--	--
Cucumber and Melons	***	*	*	--
Mango	***	--	**	**
Citrus	***	--	*	--
Banana	***	--	--	--

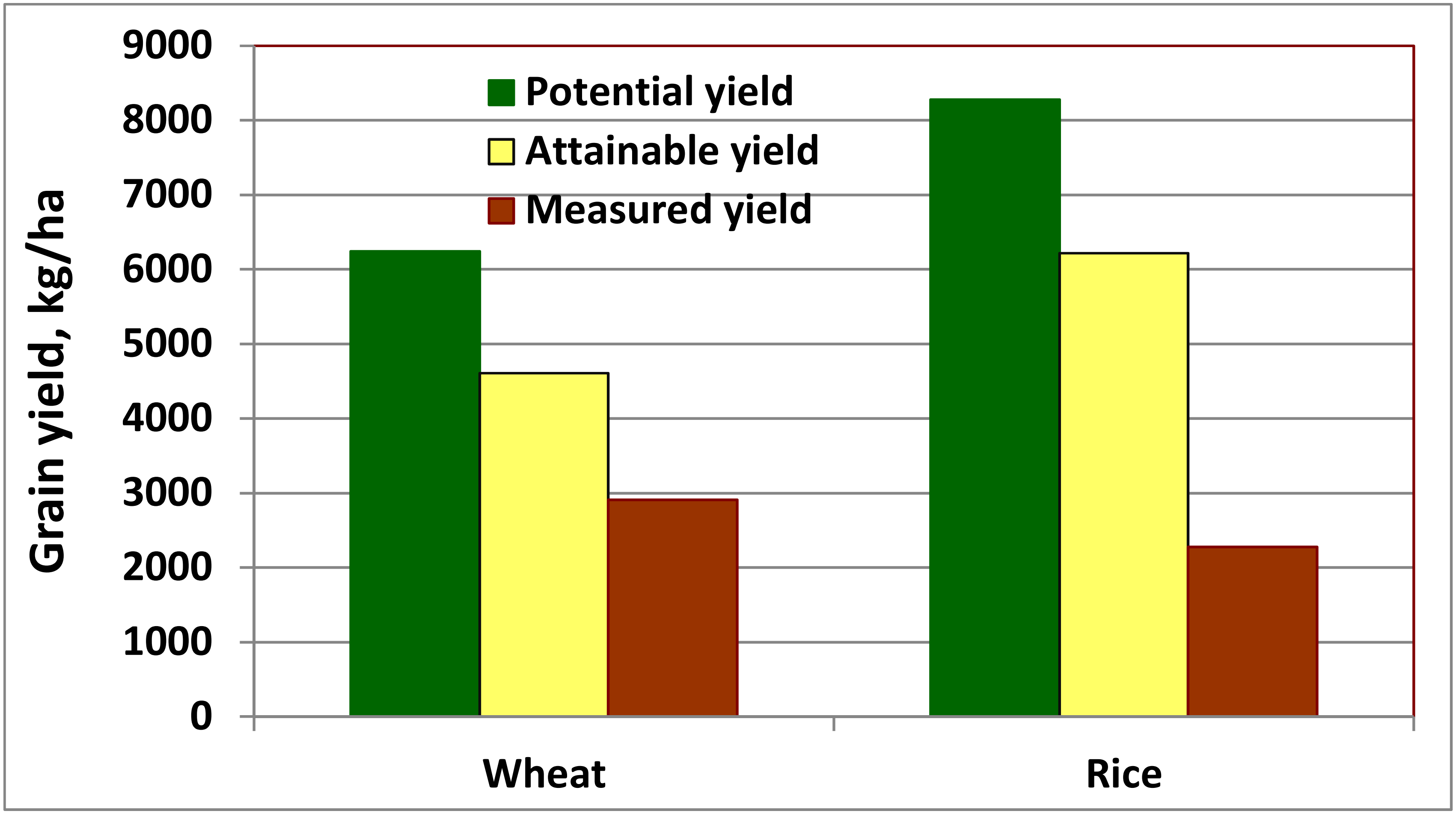
PGR Utilization by Breeders for Crop Improvement

Gaps

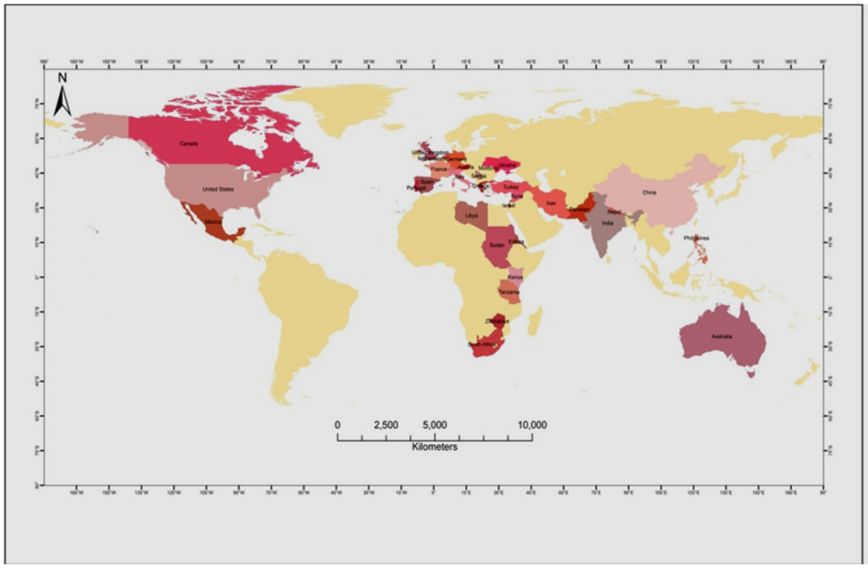
- **Narrow genetic base of breeding material**
  - Over-reliance on own working collection
  - Greater reliance on international nurseries / trials
  - Reluctance to use PGR in the breeding programmes
- Lack of long-term strategy for broadening genetic base
- **Poor characterization and evaluation status of germplasm**

Adapting to climate change and heat stress in wheat and rice:

Make full use of untapped potential of available germplasm

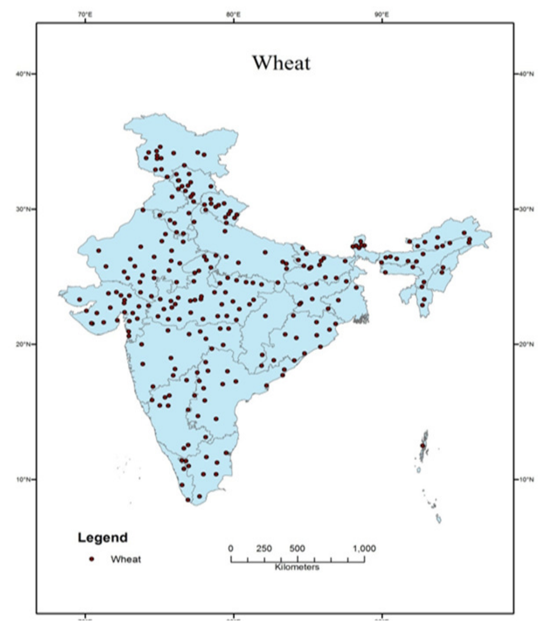


Wheat collection from different parts of the world are conserved in National Gene Bank of NBPGR

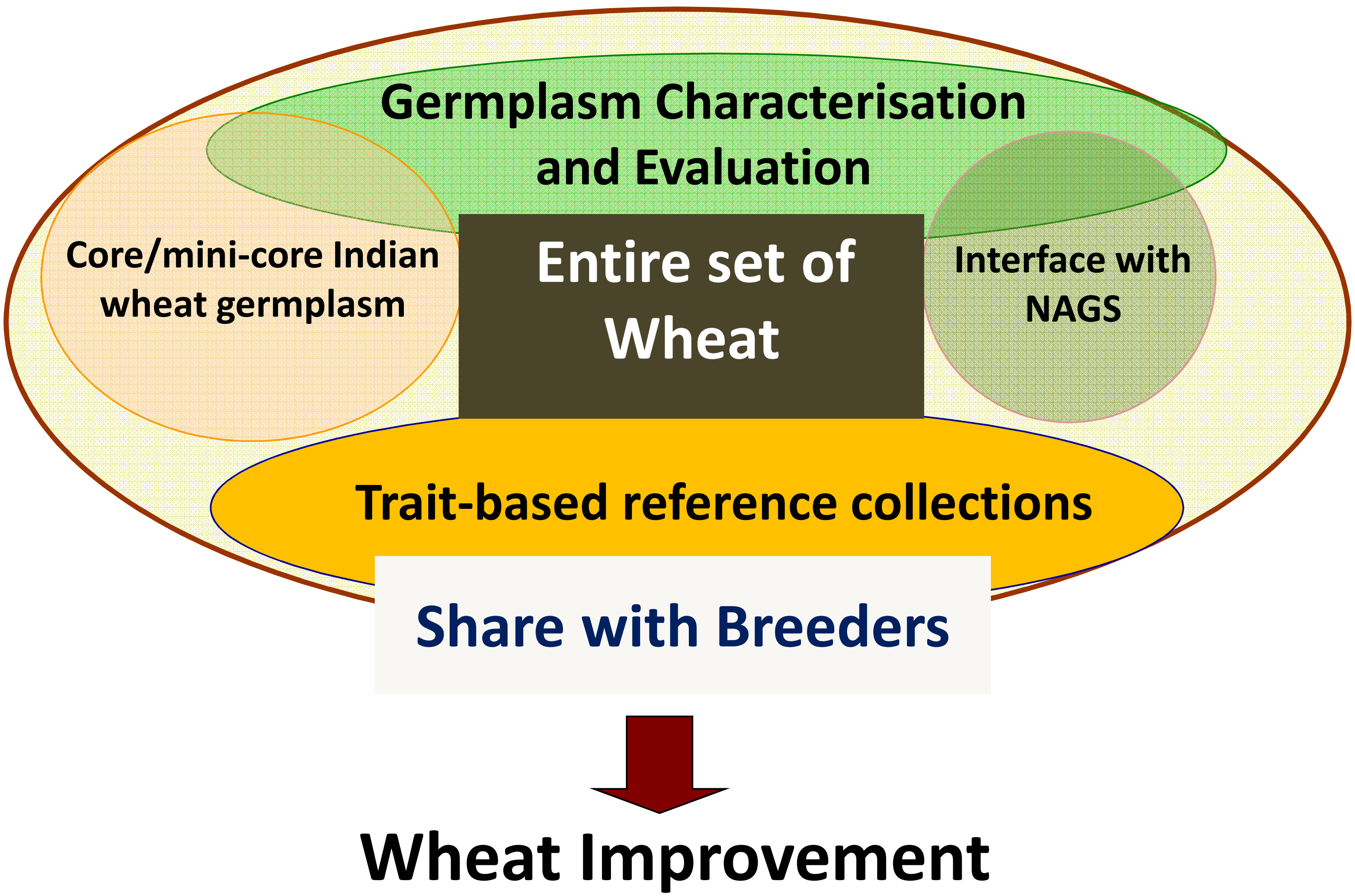


Continents	No. of accessions
Africa	166
Asia	524
Australia	322
Europe	190
North America	855
South America	1482
Others	380

Agro-climatic zones	No. of accessions
NWPZ	2187
NEPZ	67
CZ	366
PZ	327
NHZ	2272
SHZ	24

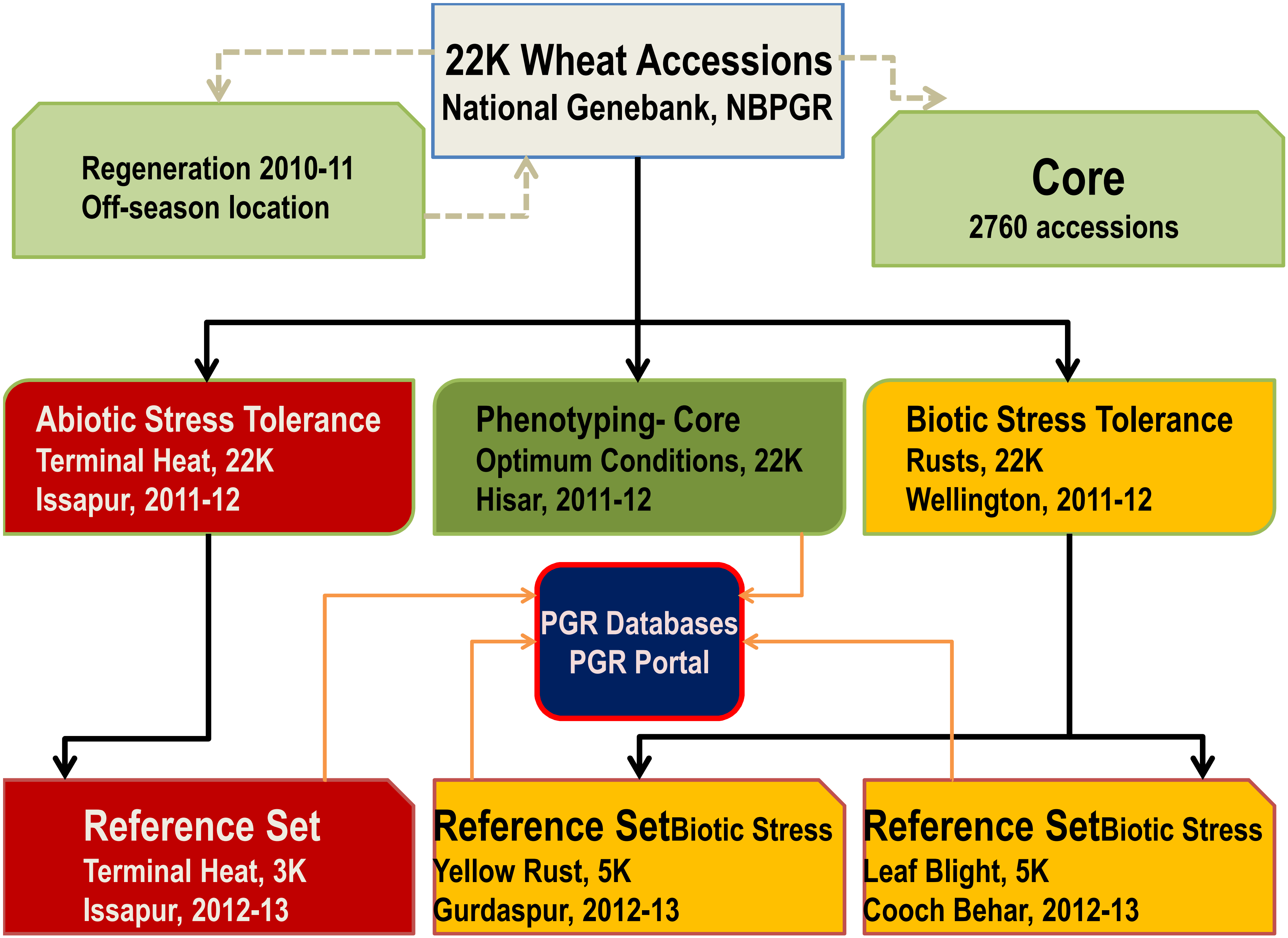


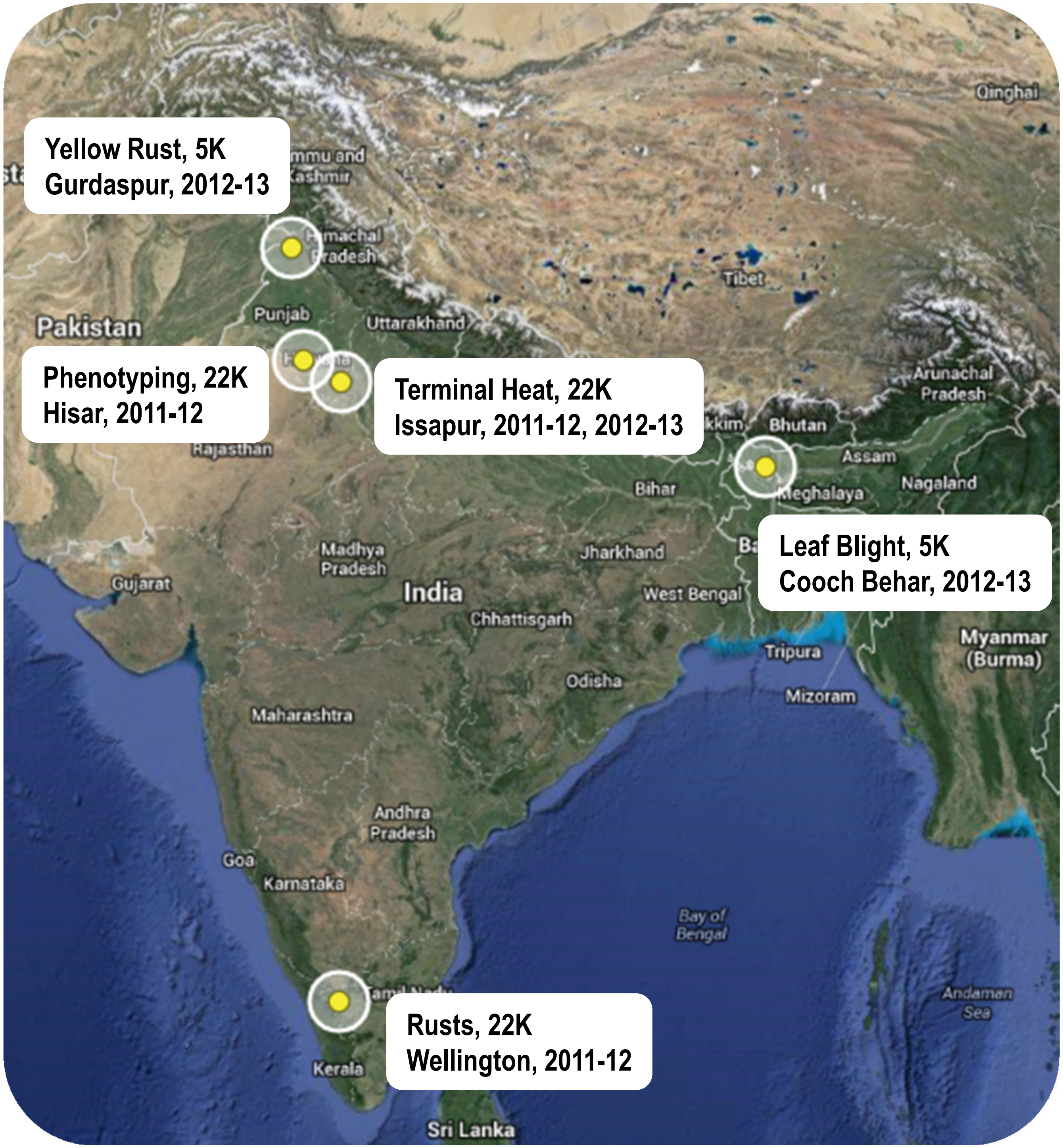
NBPGR's Initiative : Identification of Trait-specific Germplasm for wheat Improvement



NBPGR has characterized and evaluated entire set of about 22,000 wheat accessions

CCSHAU Farms, Hisar


22K Wheat Accessions
National Genebank, NBPGR
Regeneration 2010-11
Off-season location
Core
2760 accessions
Abiotic Stress Tolerance
Terminal Heat, 22K
Issapur, 2011-12
Phenotyping- Core
Optimum Conditions, 22K
Hisar, 2011-12
Biotic Stress Tolerance
Rusts, 22K
Wellington, 2011-12
PGR Databases
PGR Portal
Reference Set
Terminal Heat, 3K
Issapur, 2012-13
Reference Set Biotic Stress
Yellow Rust, 5K
Gurdaspur, 2012-13
Reference Set Biotic Stress
Leaf Blight, 5K
Cooch Behar, 2012-13



Characterization and evaluation of entire set of about 22,000 wheat accessions at different Locations in India

Characterization and evaluation of wheat germplasm

- ❖Augmented Block Design
- ❖Three rows of each accession
- ❖8 check varieties -PBW343, Raj-3765, DBW-17, C-306, DDK1025, DDK1029, UAS-415, DWR 1006 for respective species

Wheat genetic variability at its best

(2011-12)

Germplasm Evaluation for Terminal Heat Tolerance at Issapur, New Delhi

(2011-12)

- Augmented Block Design
- Single row (2.0 m)
- **8 national checks** for the respective species

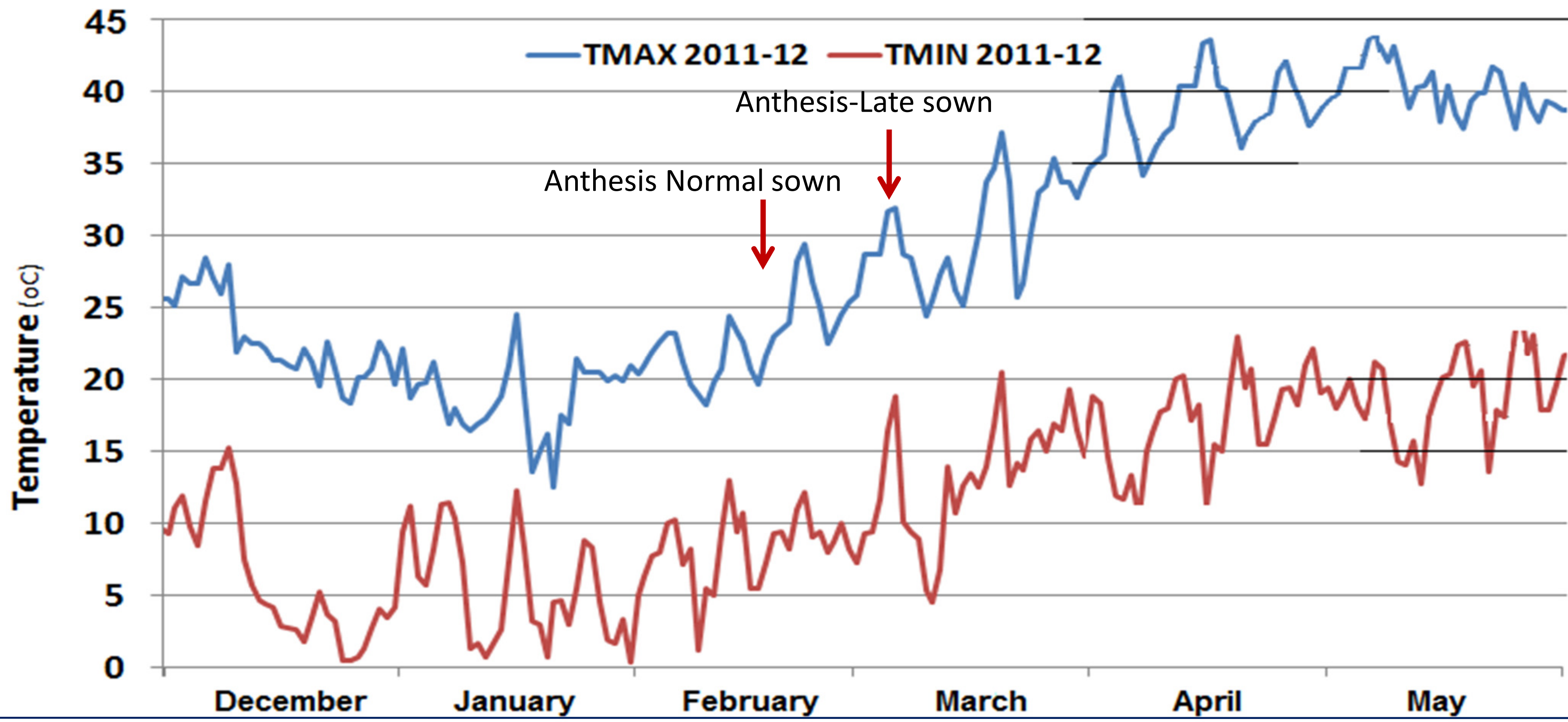
Preliminary evaluation of wheat germplasm for terminal heat tolerance

Location: NBPGR Farm, Issapur

Longitude 76 50’ , Latitude 28 40'

Timely Sown (First week of December, 2011)		
1	*Triticum aestivum*	17751
2	*T. durum*	3528
3	*T. dicoccum*	166
	Total	**21445**
Late Sown (First week of January, 2012)		
1	*Triticum aestivum*	17709
2	*T. durum*	3528
3	*T. dicoccum*	166
	Total	**21403**
	Design	**Augmented Block Design**
	Checks (8)	Kharchia 65, Raj 3765, DBW 17, C 306, DDK 1025, DDK 1029, UAS 415, DWR 1006

Daily maximum and minimum temperature at Issapur Farm (New Delhi) during *rabi* season 2011-12



Sowing	Mean Tmin		Mean Tmax	
	Sowing to anthesis	Grain growth duration (GGD)	Sowing to anthesis	Grain growth duration (GGD)
Normal	6.9	16.1	21.9	31.1
Late	7.3	22.3	23.6	37.5

Trait variability in germplasm


IC532008


IC532007

Growth habit; chlorophyll content


IC531999


IC532004

Leaf epicuticular wax

Trait variability in germplasm

IC531993

IC532004

Erect flag leaf;
Drooping flag leaf

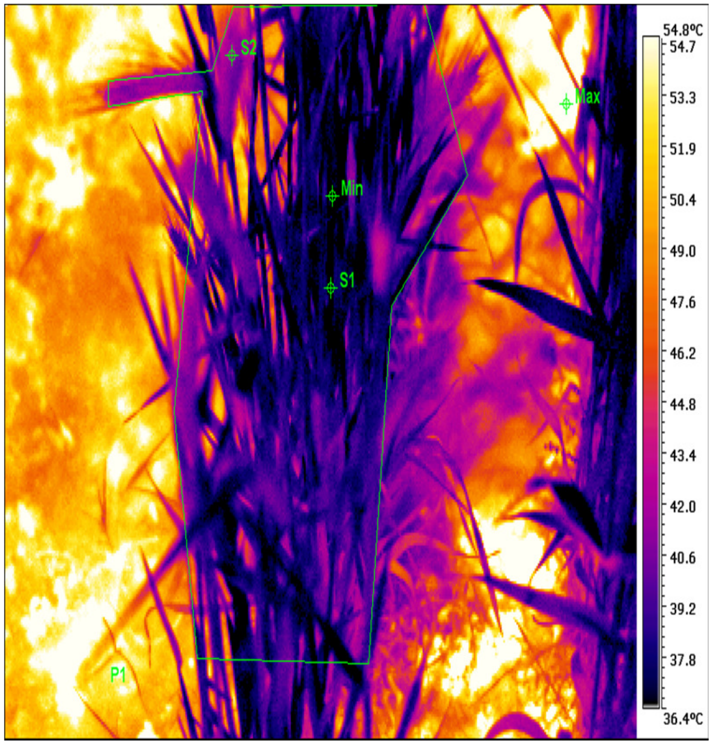
IC128215

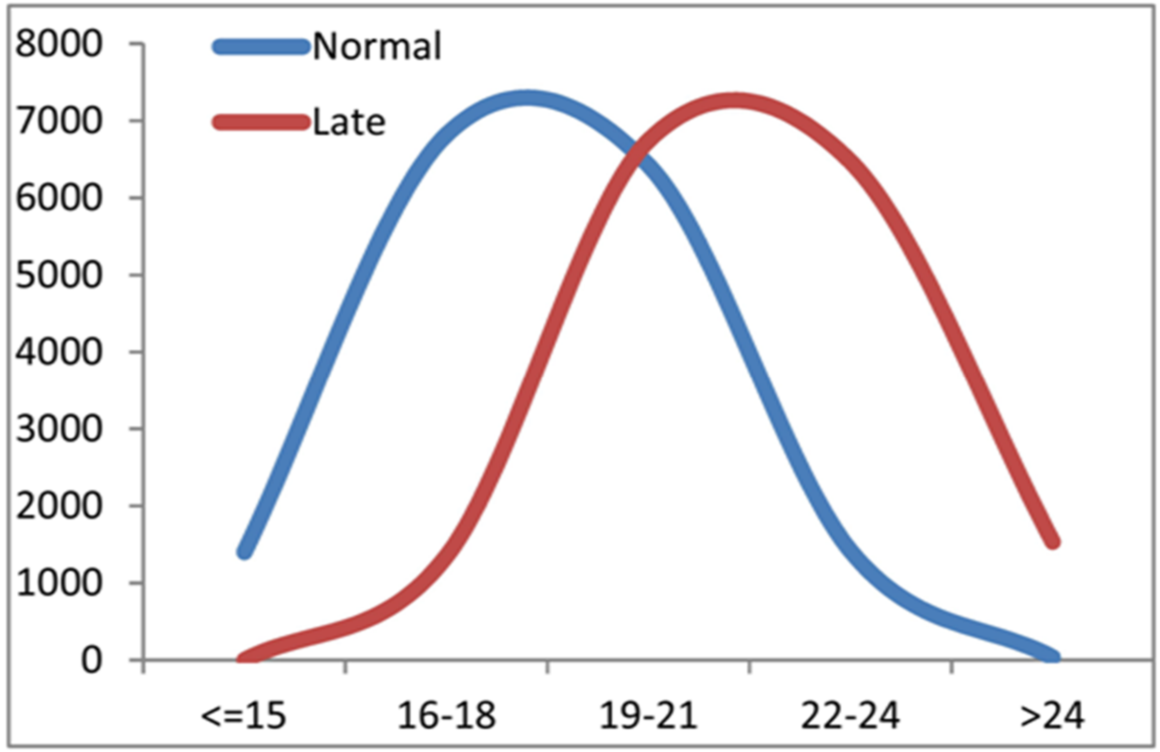
IC82434

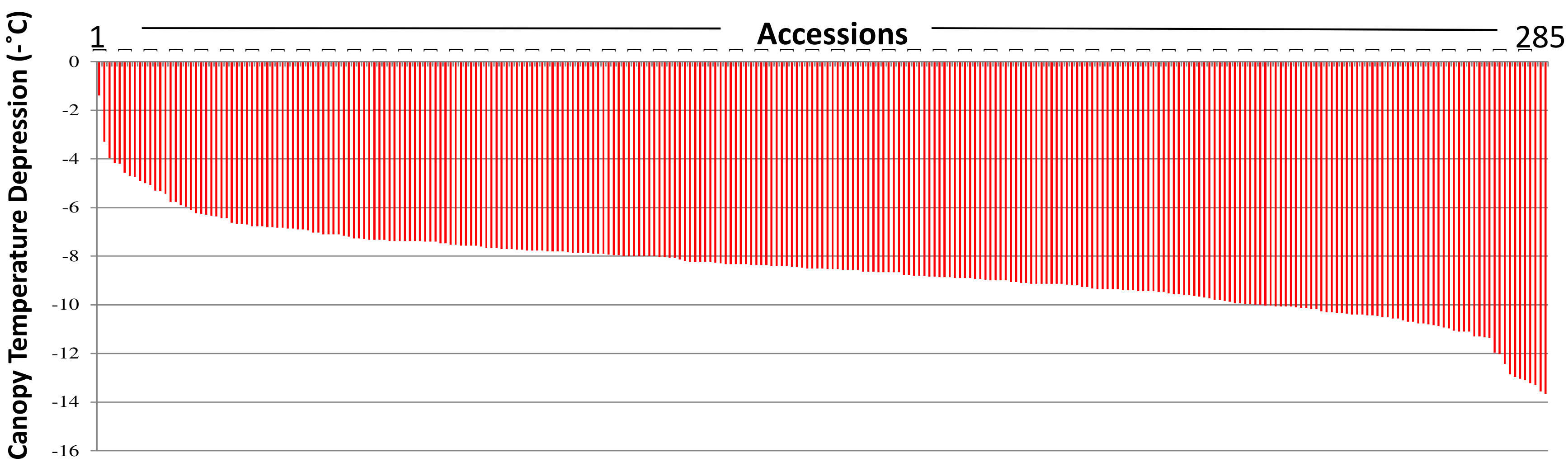
IC535412

Awn length

Canopy temperature and CTD during grain filling







Promising accessions based on grain yield and grain weight stability

	Heat susceptibility Index					
Acc. No.	Effective Tillers	Biological Yield	Grain yield	Grains per spike	Grain weight	% reduction in GW
EC573561	0.50	0.08	0.00	0.32	0.31	8.0
IC443707	0.39	0.06	0.00	0.45	0.45	11.4
IC443660	0.13	0.29	0.00	0.87	0.87	22.0
IC402028	0.52	0.08	0.00	0.49	0.49	12.5
EC575437	0.72	0.36	0.00	0.62	0.62	15.6
IC416129	0.48	0.23	0.00	0.44	0.44	11.2
EC576853	0.48	0.71	0.00	0.36	0.36	9.0
EC574839	0.48	0.71	0.00	0.36	0.36	9.0
IC539274	0.55	0.90	0.02	0.31	0.31	7.8
EC256465	0.71	0.06	0.02	0.35	0.35	8.9
IC572928	0.30	0.08	0.11	0.33	0.33	8.3
IC547640	0.30	0.22	0.18	0.81	0.81	20.5

In tolerant genotypes, sensitivity in one yield component is compensated by tolerance in other yield components

Reference Set for Terminal Heat Tolerance

3,019 wheat accessions were selected based on 5 parameters (canopy temperature depression, leaf waxiness, days to maturity, grain yield per plant and 100 seed weight) related to Terminal Heat Tolerance, and **further validated at NBPGR, Issapur farm during *Rabi* 2012-13.**

Reference Set for Terminal Heat Tolerance

(*Rabi* 2012-13)

•A set of 3202 wheat accessions with wide variation for **canopy temperature depression, leaf waxiness, days to maturity, grain yield per plant** and **1000 seed weight** were evaluated under terminal heat stress under two sowing dates during Rabi 2012-13 at NBPGR, Issapur.

Identification of Germplasm for Tolerance to Biotic Stresses at Wellington

Total wheat accessions assayed phenotypically	20683
Accessions resistant to stem rust	19179
Accessions resistant to leaf rust	6263
Accessions resistant to stripe rust	12339
Accessions resistant to stem and leaf rust	6082
Accessions resistant to stem and stripe rust	11580
Accessions resistant to leaf and stripe rust	5238
Accessions resistant to stem, leaf and stripe rust	5081
Accessions resistant to powdery mildew	8516

Reference Set for Biotic Stress Tolerance

From the initial screening of 20,660 wheat accessions at Wellington, a set of 5,081 accessions was identified as tolerant to stem, leaf and stripe rusts. These lines have been further validated at PAU, Gurdaspur, Punjab (NWPZ) and UBKV, Cooch Behar, West Bengal (NEPZ) during *Rabi* 2012-13 and **513 accessions have been indentified as tolerant to multiple diseases.**

Application of Genomics Tools

Trait-based reference collections

Association analysis

Genome wide association

Candidate gene approach

SNP haplotyping

Phenotyping for target traits

Specific alleles

SNP markers

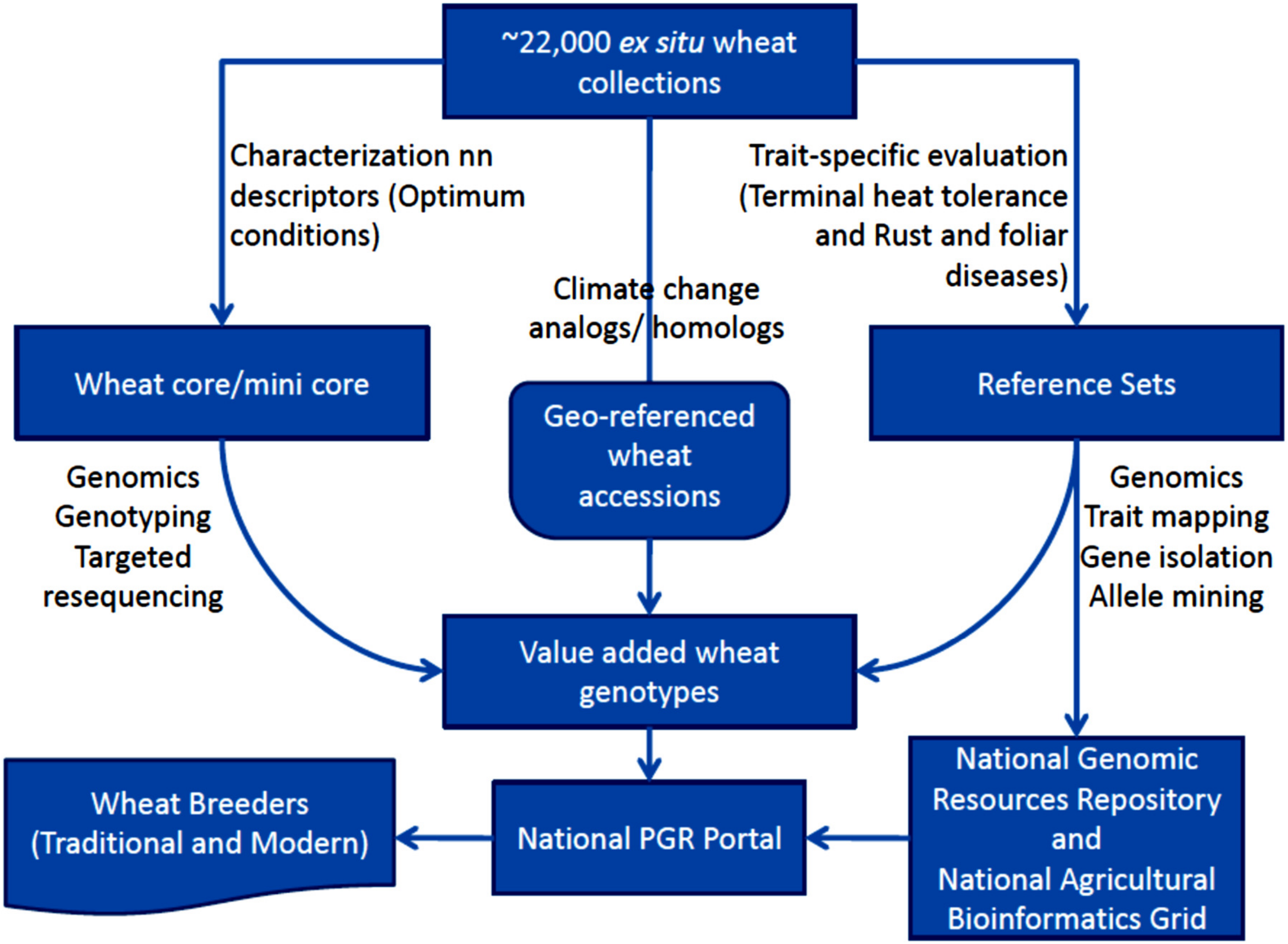
M.A.S

Novel genes

Validation by classical genetic approaches

Genetic transformation

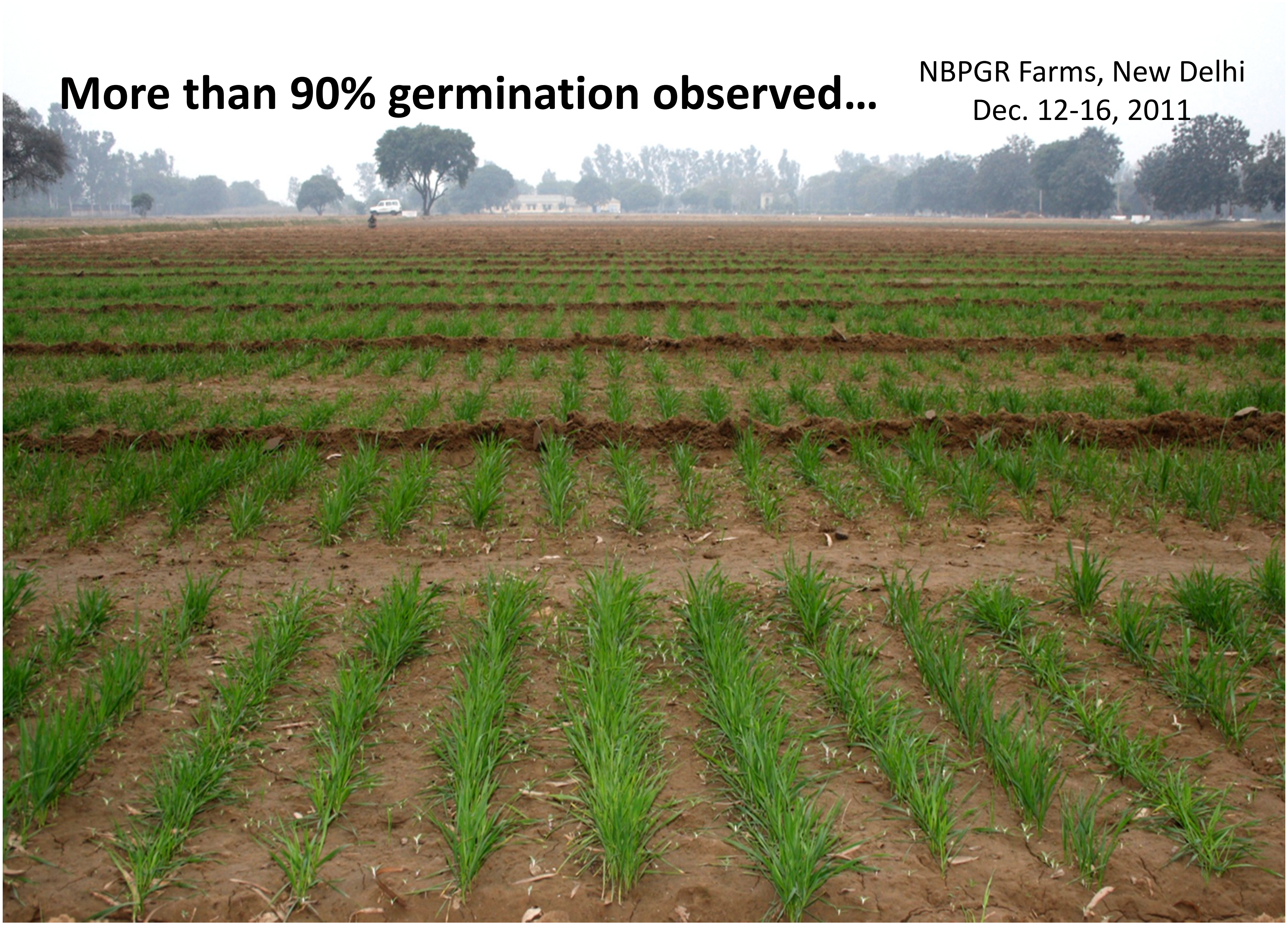
Roadmap


~22,000 *ex situ* wheat collections
Characterization nn descriptors (Optimum conditions)
Climate change analogs/ homologs
Trait-specific evaluation (Terminal heat tolerance and Rust and foliar diseases)
Wheat core/mini core
Geo-referenced wheat accessions
Reference Sets
Genomics Genotyping Targeted resequencing
Genomics Trait mapping Gene isolation Allele mining
Value added wheat genotypes
Wheat Breeders (Traditional and Modern)
National PGR Portal
National Genomic Resources Repository and National Agricultural Bioinformatics Grid

Team Work

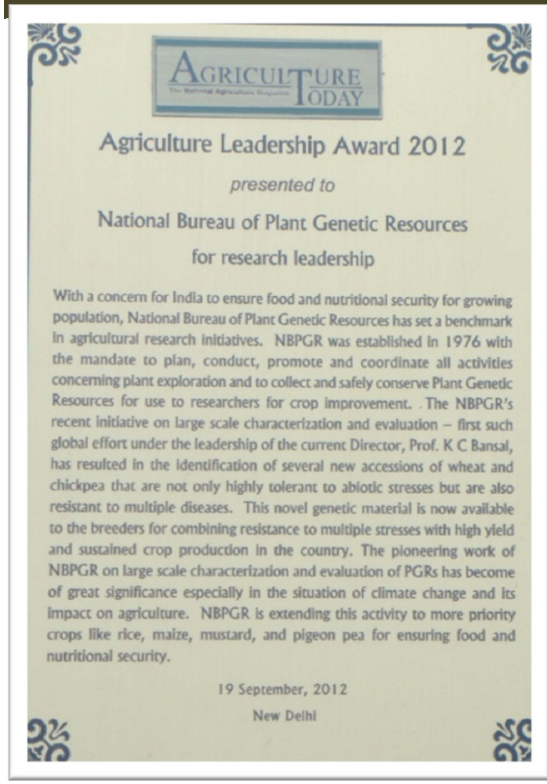
More than 90% germination observed…

NBPGR Farms, New Delhi
Dec. 12-16, 2011



Large scale characterization and evaluation of germplasm

Research Leadership Award Conferred on NBPGR



AGRICULTURE TODAY
The National Agriculture Magazine

Agriculture Leadership Award 2012

presented to

National Bureau of Plant Genetic Resources

for research leadership

With a concern for India to ensure food and nutritional security for growing population, National Bureau of Plant Genetic Resources has set a benchmark in agricultural research initiatives. NBPGR was established in 1976 with the mandate to plan, conduct, promote and coordinate all activities concerning plant exploration and to collect and safely conserve Plant Genetic Resources for use to researchers for crop improvement. The NBPGR's recent initiative on large scale characterization and evaluation – first such global effort under the leadership of the current Director, Prof. K C Bansal, has resulted in the identification of several new accessions of wheat and chickpea that are not only highly tolerant to abiotic stresses but are also resistant to multiple diseases. This novel genetic material is now available to the breeders for combining resistance to multiple stresses with high yield and sustained crop production in the country. The pioneering work of NBPGR on large scale characterization and evaluation of PGRs has become of great significance especially in the situation of climate change and its impact on agriculture. NBPGR is extending this activity to more priority crops like rice, maize, mustard, and pigeon pea for ensuring food and nutritional security.

19 September, 2012

New Delhi

Summary

- Wide variability was found in the gene pool for heat tolerance and other agronomic traits that can be used for wheat improvement.
- Heat stress under delayed sowing reduces grain yield due to reduction in biomass (due to reduced tillering), grains per spike and grain weight, while harvest index was unaffected.
- Wheat germplasm showed very high variability for these traits and accessions with high stability for these component traits have been identified.
- Canopy temperature has a negative effect on grains per spike and grain weight, and thus genotypes with very high CTD identified in this study will be useful in stabilizing these yield components under heat stress.
- ~**2000 germplasm lines showing less than 10% yield reduction have been identified. These lines will be greatly useful as donors as well as for identification of genes/ QTLs for heat tolerance in various component traits.**

Future Plan

- The trait specific reference set for terminal heat tolerance developed in this project will be utilized for association mapping and/or Linkage mapping, and allele mining for target trait.

- Identified germplasm lines with higher level of heat tolerance can be included as a donor parent in breeding program for developing new promising heat tolerant wheat cultivars.

Utilization of *ex situ* collection using climate analogues for enhancing adaptive capacity to climate change

<u>Crops:</u>

1. Wheat
2. Pearl millet
3. Sorghum
4. Chickpea
5. Pigeonpea

Potential of Underutilized Crops


Amaranth


Rice bean


Perilla


Tumba

Minor cereal: Job's tear; **Pseudocereals:** Amaranth, Buckwheat, Chenopods; **Legumes:** Adzuki bean, Faba bean, Rice bean & Winged bean; **Oilseeds:** Perilla & Paradise tree; **Vegetables:** Kankoda & Kalingada; **Industrial crops:** Jatropha &Tumba


Buckwheat


Kankoda


Kalingada


Jatropha

Global Consultation on Use and Management of Agrobiodiversity for Sustainable Food Security 12-14 February, 2013

Priority areas identified for South-South cooperation and an operational roadmap for strengthening partnership in conservation and utilization of genetic resources developed

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NBPGR, New Delhi, December 13, 2011

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CIMMYT

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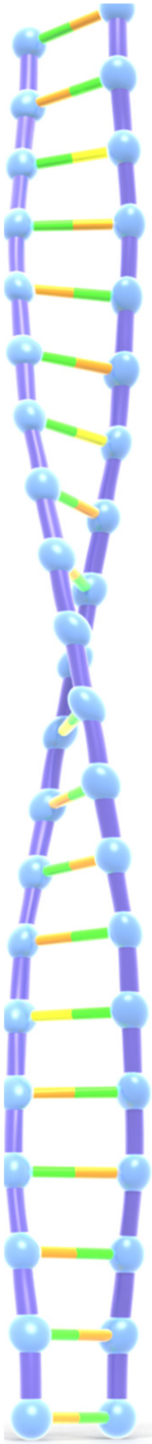
Dr. Ravi B Singh
Dr. Arun Joshi

Dr. Mathew Reynolds
Dr. Alistair Pask

ICARDA

NBPGR scientists and staff



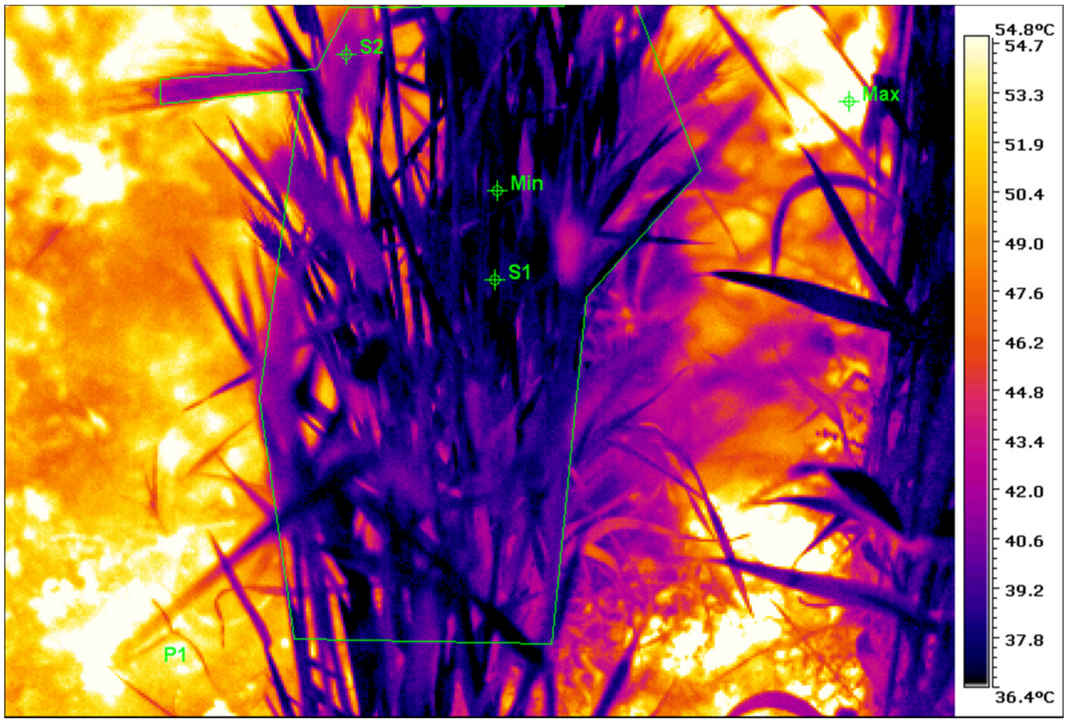
Thank You

भाकृअनुप
ICAR

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch

Infrared Image analysis



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Min Temp	30.1°C

- Ranges from 0 to 1
- At which recorded

Object Parameter	Value
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Min	30.1°C
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S2	37.4°C
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P1:MaxTemp	48.7°C
P1:MinTemp	30.1°C

Max and min temp of the image

S1: foliar temp and S2: head temp in the image

Avg, max and min temp of the POLYGON