Bread Wheat Breeding Program at CIMMYT
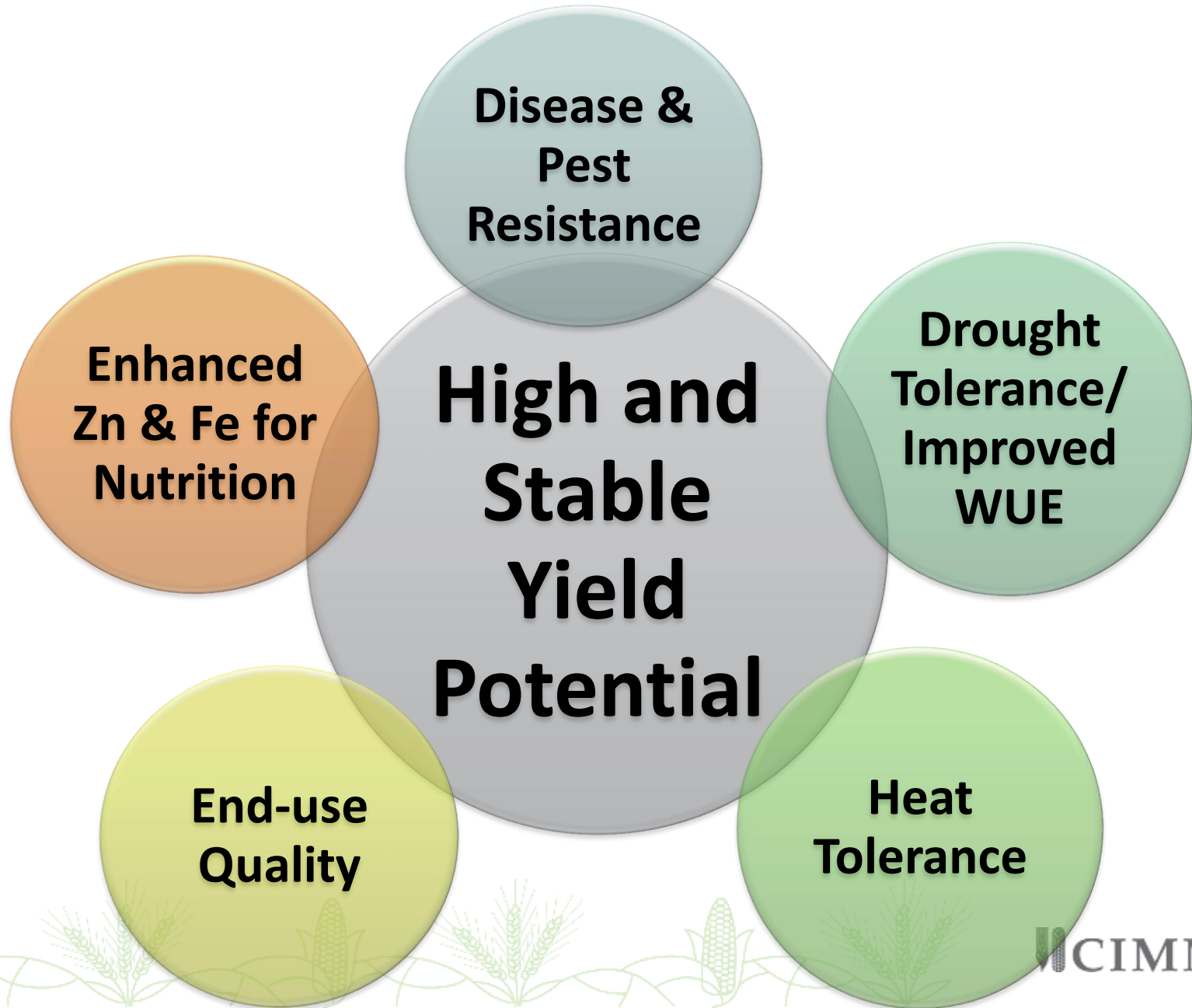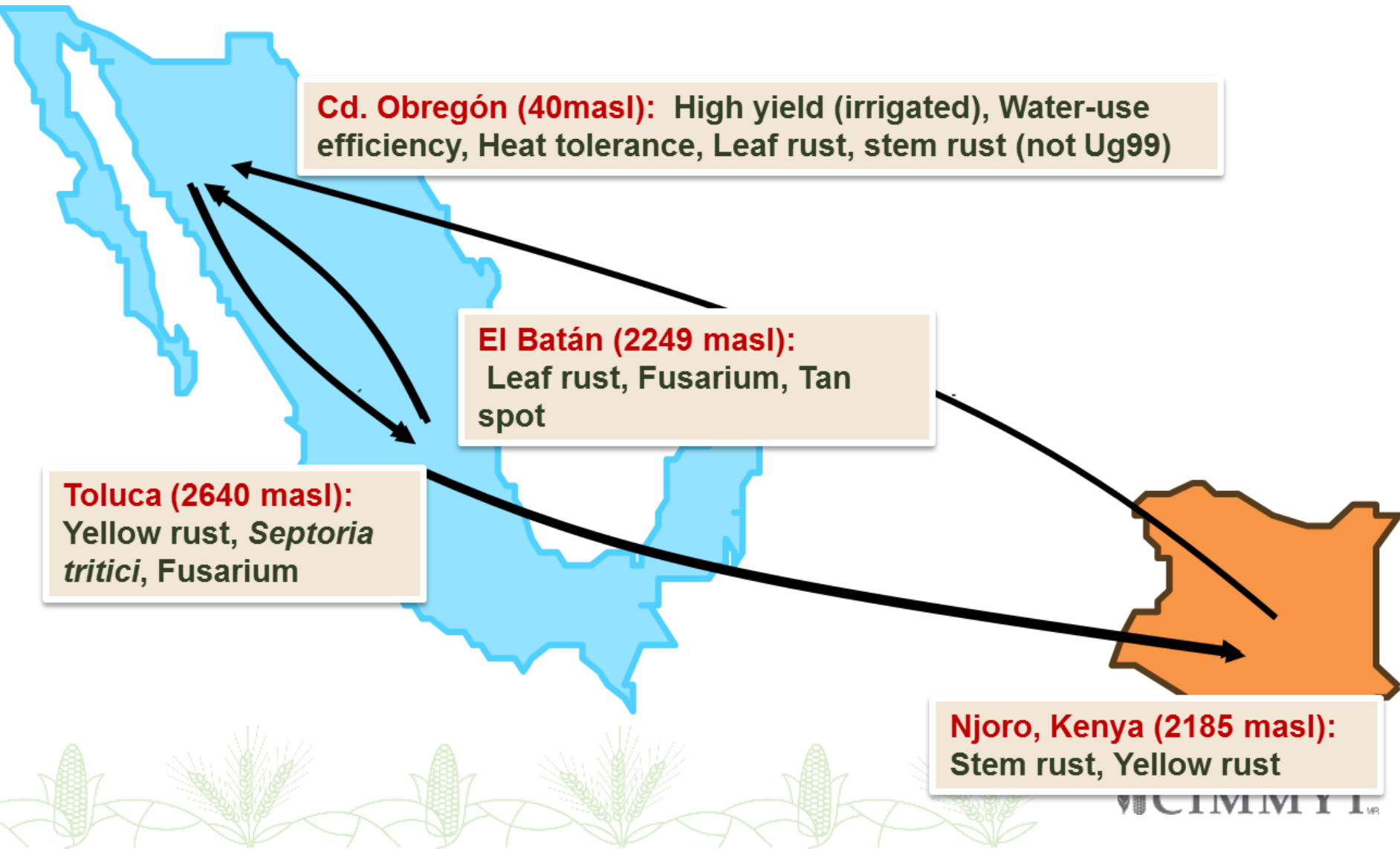
Suchismita Mondal

Wheat Breeder

International Maize and Wheat Improvement Center, CIMMYT

CIMMYT

# Wheat breeding priorities

Disease & Pest Resistance

Enhanced Zn & Fe for Nutrition

High and Stable Yield Potential

Drought Tolerance/ Improved WUE

End-use Quality

Heat Tolerance

CIMMYT

Up-scaled breeding and testing to deliver genetic gain (5 years breeding cycle)

Cd. Obregón (40masl): High yield (irrigated), Water-use efficiency, Heat tolerance, Leaf rust, stem rust (not Ug99)

El Batán (2249 masl): Leaf rust, Fusarium, Tan spot

Toluca (2640 masl): Yellow rust, *Septoria tritici*, Fusarium

Njoro, Kenya (2185 masl): Stem rust, Yellow rust

CIMMYT

Cd. Obregon Cycle

- Ciudad Obregon, Sonora, Mexico
  - Lat: 27°22' N, Long : 109°55' W
  - Elevation : 40m above sea level
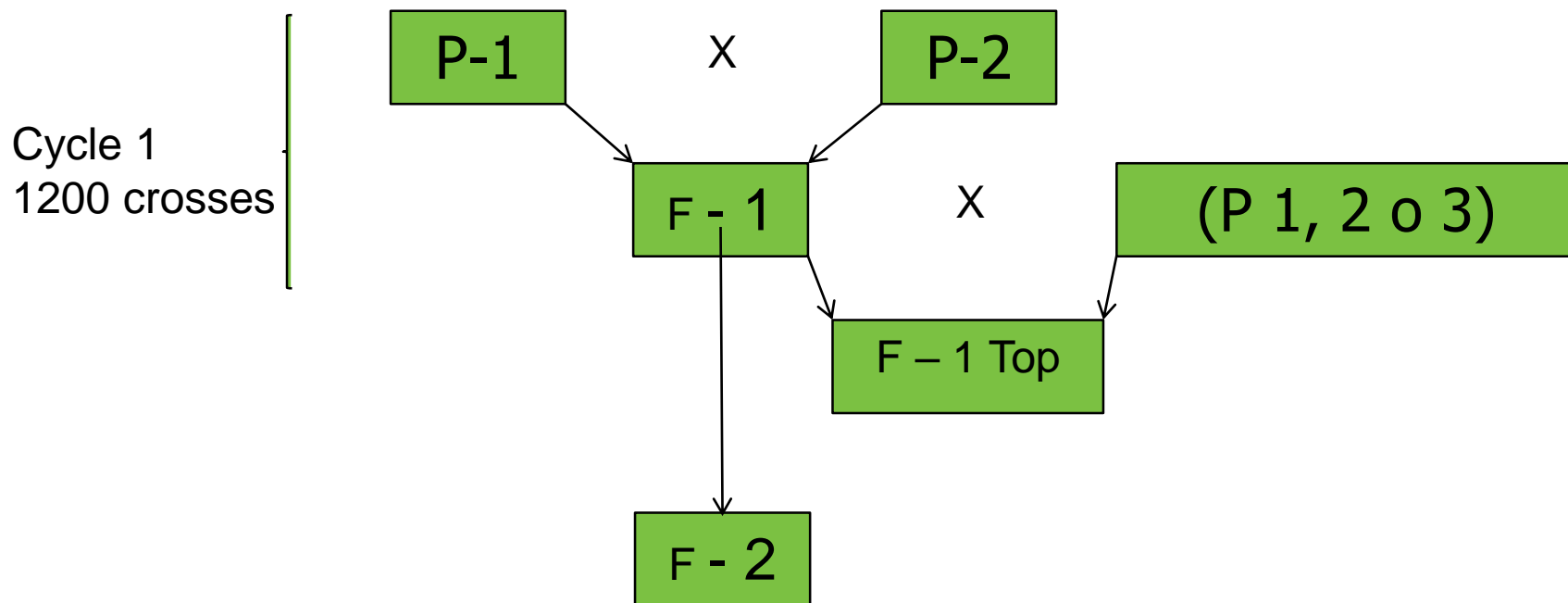 - Hot desert climate

CIMMYT
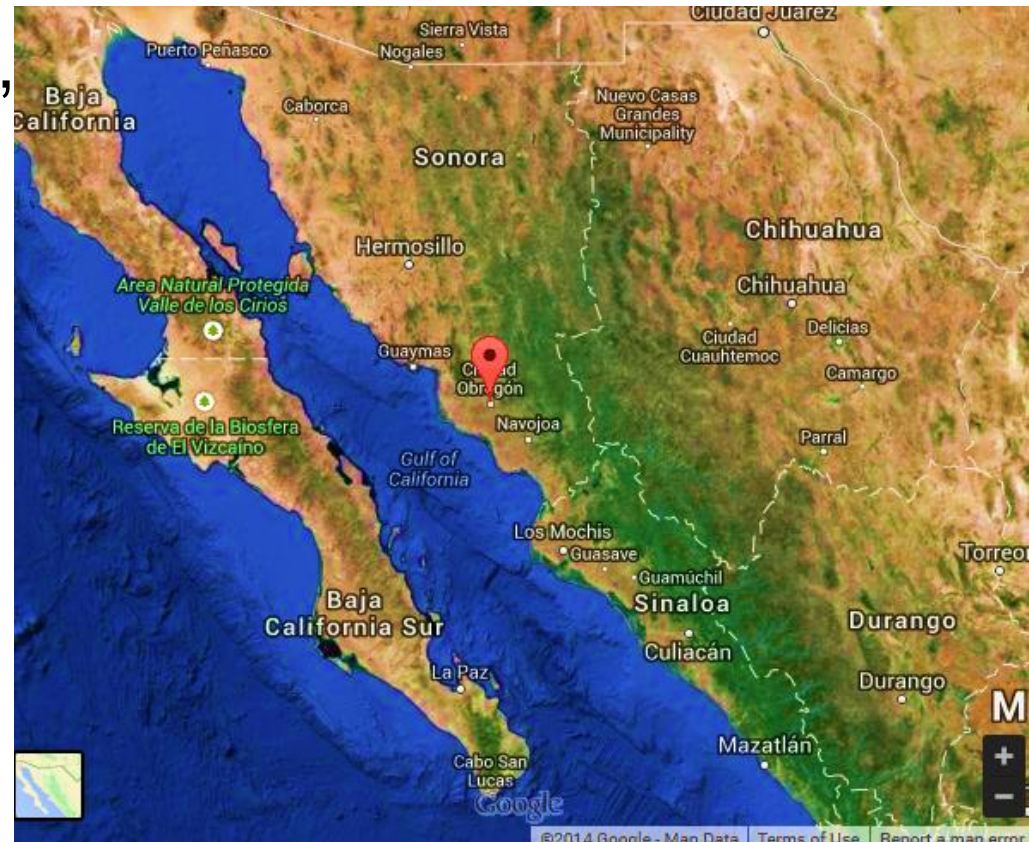
Obregon Cycle

- Planting in November – 60 ha or 148 acre
- Field maps prepared in Fieldmap app.

Hand Planting (6 ha or ~ 70-80K lines)

Making crosses & generation advance

Cycle 1
1200 crosses

P-1   X   P-2

F - 1   X   (P 1, 2 o 3)

F – 1 Top

F - 2

The crossing plan is prepared in Excel based on all available information about the parents

Eg. of data sheets

We can have 60-70 columns of data to make decisions regarding crosses

Crossing in field

Cycle 2
1500 populations
Each population
2000 plants

4-5 ha or 9-12 acre

F - 2

SB

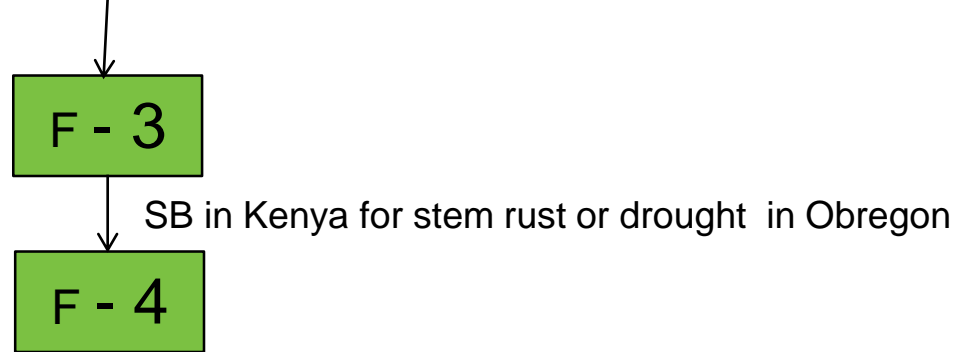**SB** : selected bulk approach for selection in segregating generation

Selection: Resistance to rust, agronomic type, height

CIMMYT

Cycle 3
2000 populations evaluated both in Cd. Obregon & Njoro

F - 3

SB in Kenya for stem rust or drought in Obregon

F - 4

Cd. Obregon, Mexico under drought   **Njoro, Kenya Stem rust evaluations**

Selection: Yield, NDVI, CT

Selection: Resistance to stem rust
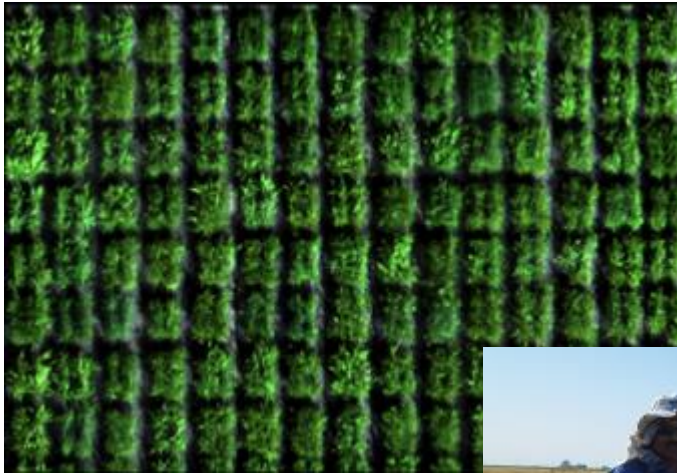
CIMMYT

Cont. Breeding cycle
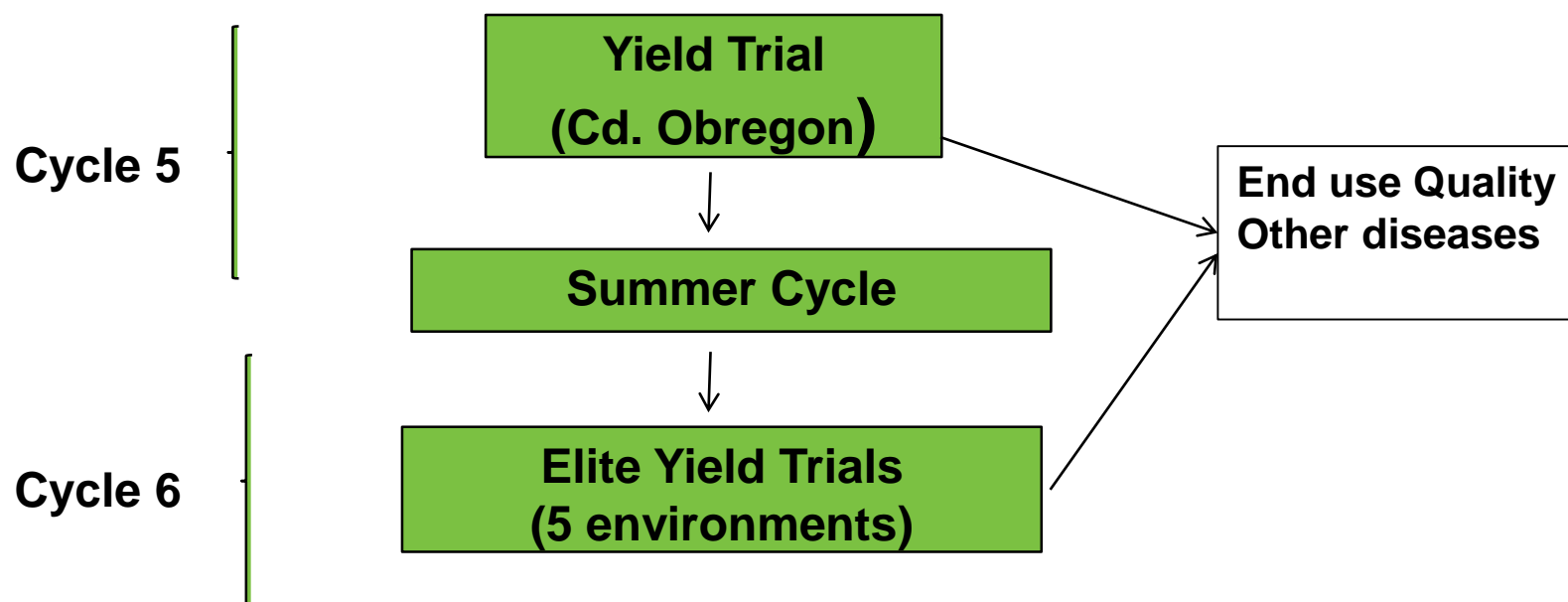
Cycle 4
~ 60,000 head rows

F - 5

F - 6
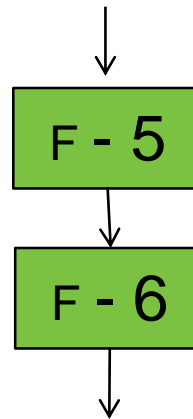
HR o IP   HR – head to row or IP – individual plant to row

Grain selection
~ 100,000 envelopes
2 week activity
Selection: Grain size, grain diseases

Cont. breeding cycle

Cycle 5

Yield Trial (Cd. Obregon)

↓

Summer Cycle

↓

Cycle 6

Elite Yield Trials (5 environments)

End use Quality Other diseases

EYTs are tested across 6 environments: Melga (Flat), Bed, Early Heat, Drought, Heat

‖CIMMYT.

Grain yield evaluations advanced lines
Cd. Obregon, Mexico

Bed sowing normal irrigation

1st year Yield Trial, 9044 lines, 323 trials, 2 reps
20,000 plots

Late heat sowing in beds

Data collection

- Data collection using KSU – Fieldbook app

- Challenges –
  - CIMMYT database
  - Reformating current files

CIMMYT

Harvest and Sowing

~40,000 yield bags are arranged and weighed

- Materials are threshed and prepared for sowing in EI Batan and Toluca

- 2-3 weeks in between harvest threshing and sowing

CIMMYT.

Final Information from Cd. Obregon

Most advanced yield testing : Information columns range between 100-150 (across years and locations of evaluations) Utilized for decision making of Internationally distributed germplasm

# 81 Countries receiving CIMMYT Spring Wheat nurseries 2016/17

Possibilities with high throughput phenotyping in wheat breeding

- Aerial and UAV based HTP implemented
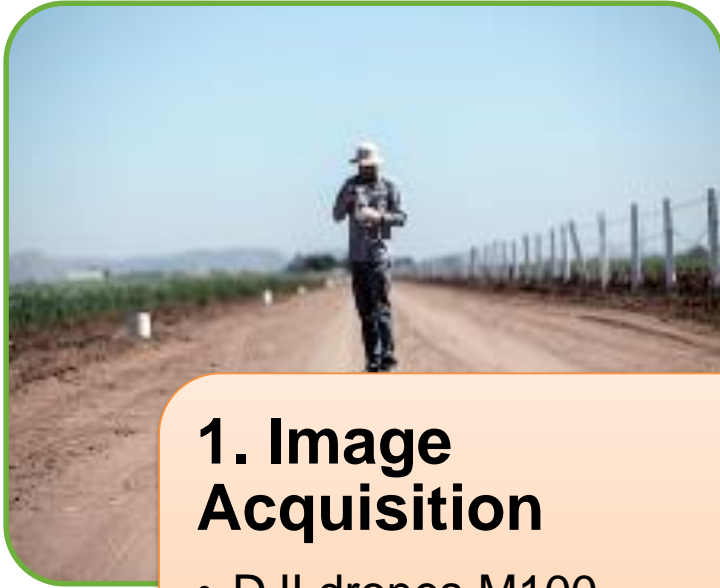- CT and NDVI highly correlates with grain yield (r =0.5-0.7)

Looking forward:

- Complementing early generation selections with HTP

- Algorithms to estimate other agronomic traits, e.g. heading (days) and plant height

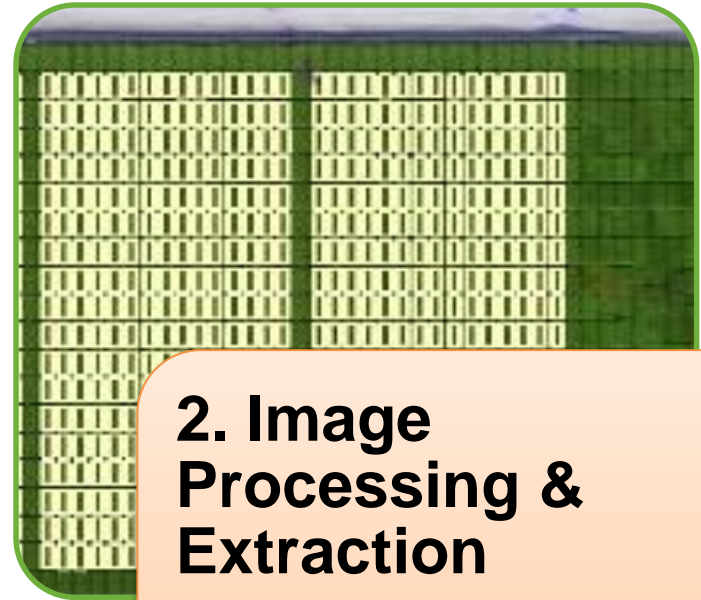- Evaluating feasibility of assessing certain foliar disease
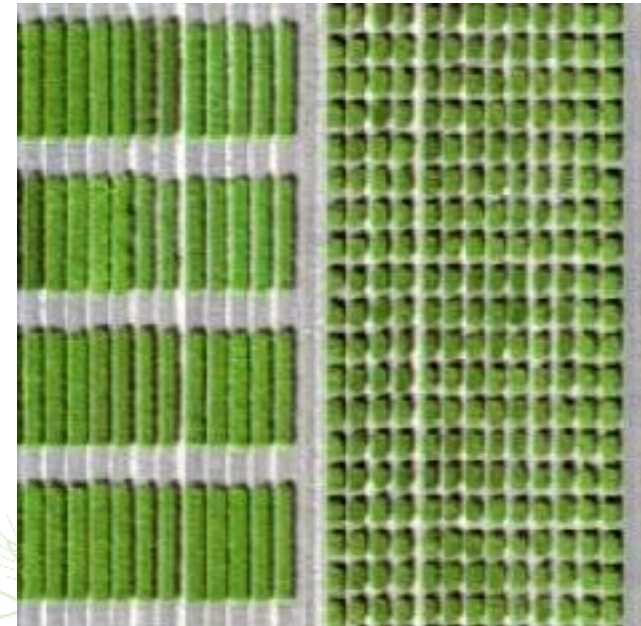
Phenomics in Breeding pipeline

1. Image Acquisition

- DJI drones M100
- Red edge camera
- Thermal camera
- Hyperspectral camera

2. Image Processing & Extraction

- Generation of ortho - mosaics
- Phenotypic trait extractions

CIMMYT

1. Image Acquisition

- DJI drones M100
- Red edge camera
- Thermal camera
- Hyperspectral camera

CIMMYT

1ˢᵗ Year Yield trials

2ⁿᵈ Year Yield trials

Head rows/ plant to rows

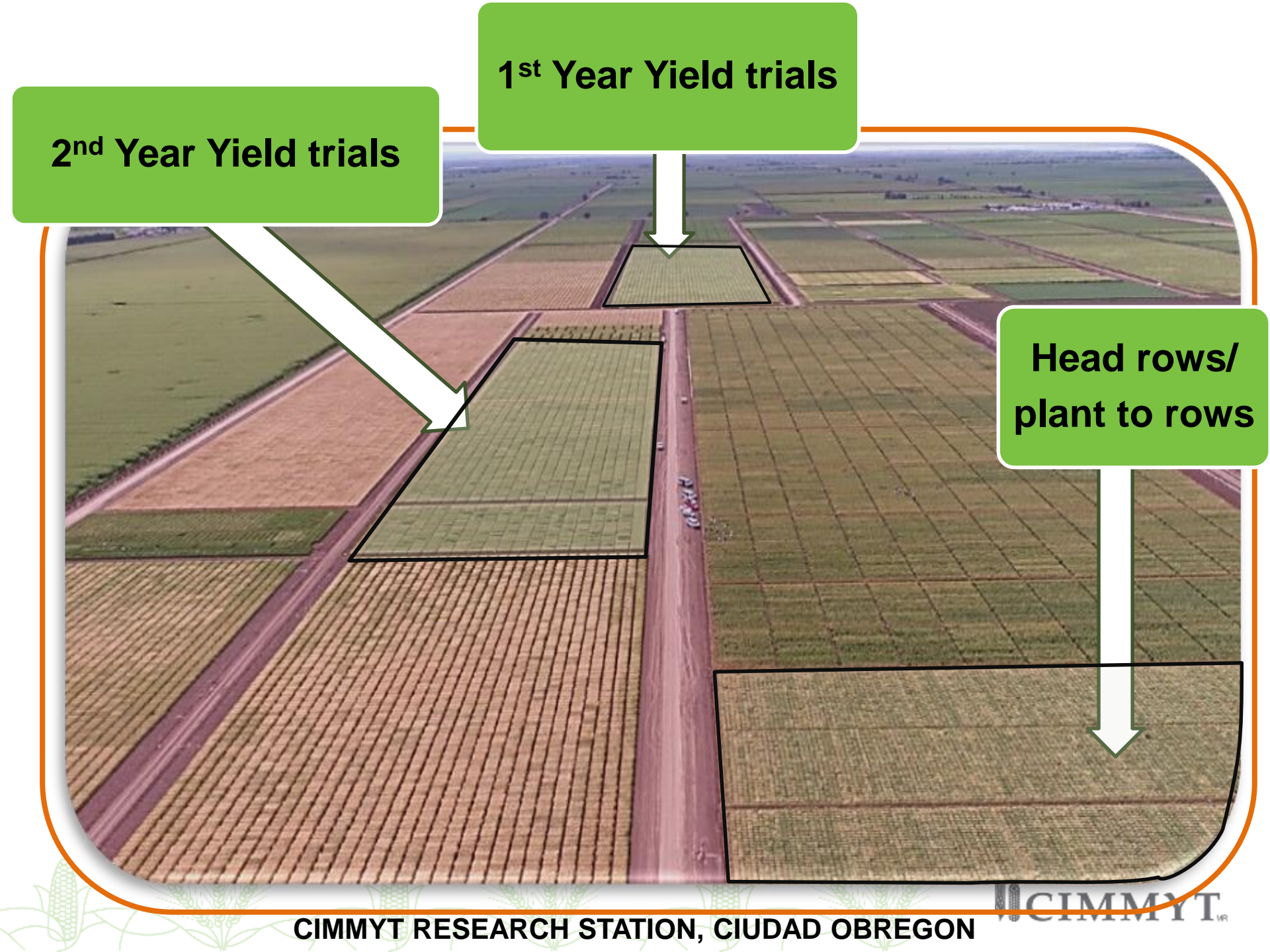CIMMYT RESEARCH STATION, CIUDAD OBREGON

Image Acquisition

- Around 25 ha of land area

- Survey ground control points

- Mission Planner (free software) – flight plans

- 3 days – time between 10.30 am till 2.00 pm

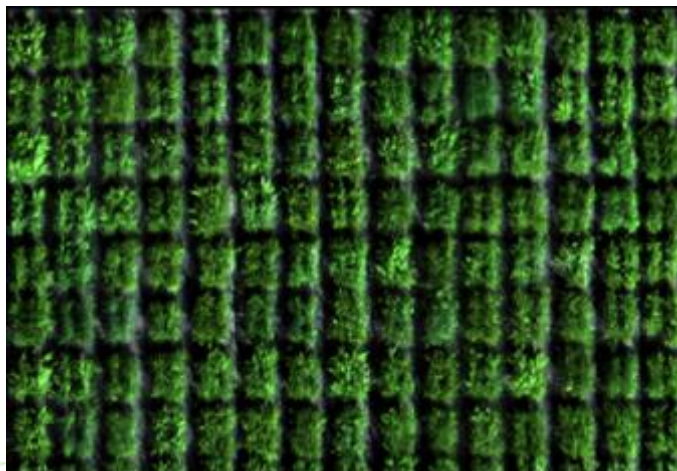- Heading till physiological maturity

NDVI and vegetation indices

RedEdge, MicaSense
Bands: 475, 560, 668, 840, 717 nm
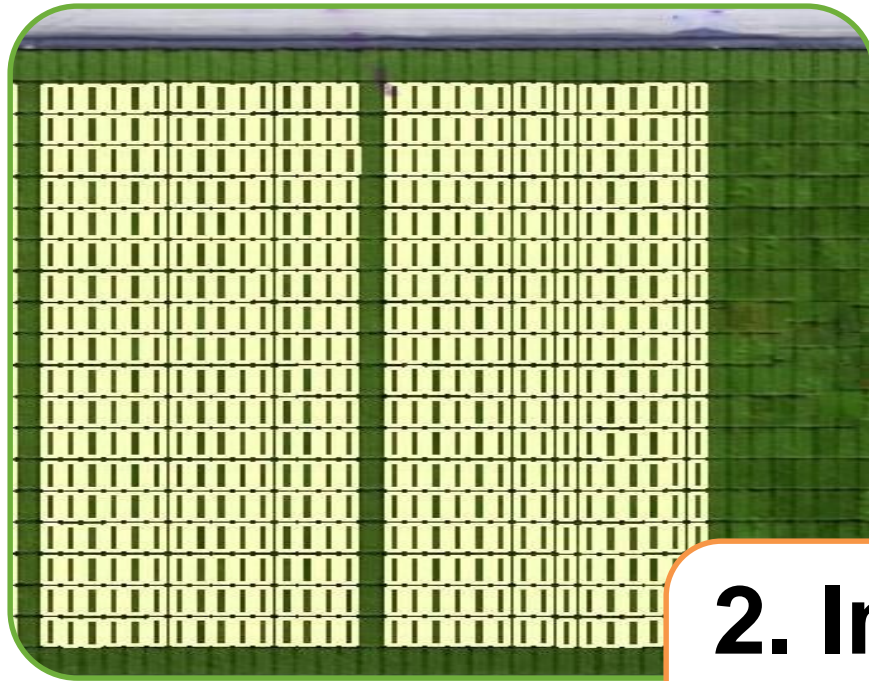Measure: NDVI, SR
GSD at 30cm: 2cm/pixel

Thermography

Zenmuse XT, DJI/FLIR
Range: 8-14 µm
GSD at 30m: 4 cm/pixel

Hyperspectral

Micro-Hyperspec, Headwall Photonics
Range: 600 – 1700 nm
n. bands: 267
GSD at 30m: 1.8 cm/pixel

2. Image Processing & Extraction

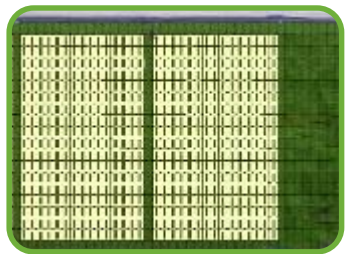- Generation of ortho -mosaics
- Phenotypic trait extractions

Image Processing & Extraction

- Pipeline in development and use (Red-edge camera)
  - ➢ Agisoft Photoscan: automated by python scripts (by Kevin Wang, KSU)

    Code – github.com/xwangksu/uavBatch

Image Processing & Extraction

Photogrammetry processing

Raw image processing

Radiometric calibration

Others (i.e. lens distortion correction)

Orthophoto & 3D DEM construction

Align and geo-reference pre-processed images with surveyed GCPs

Stitch images to generate dense point cloud

Generate orthomosaic and DEM
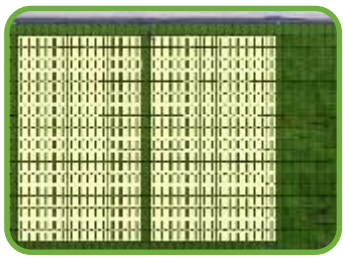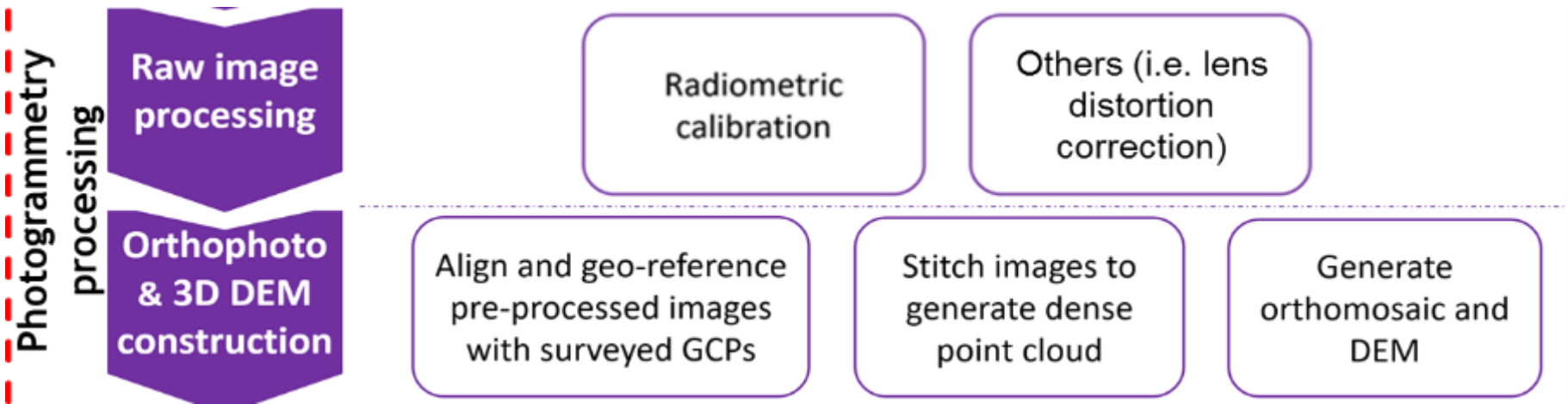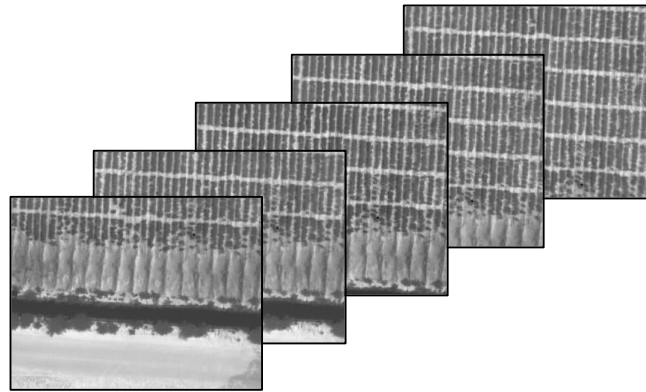
- Time reduction from months to weeks
- Extracted data available by the end of cycle
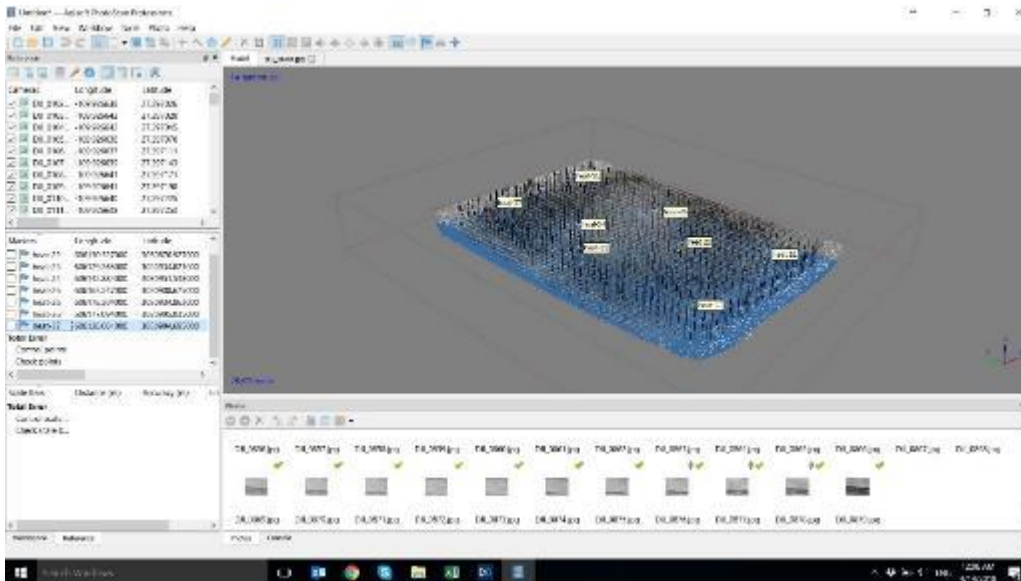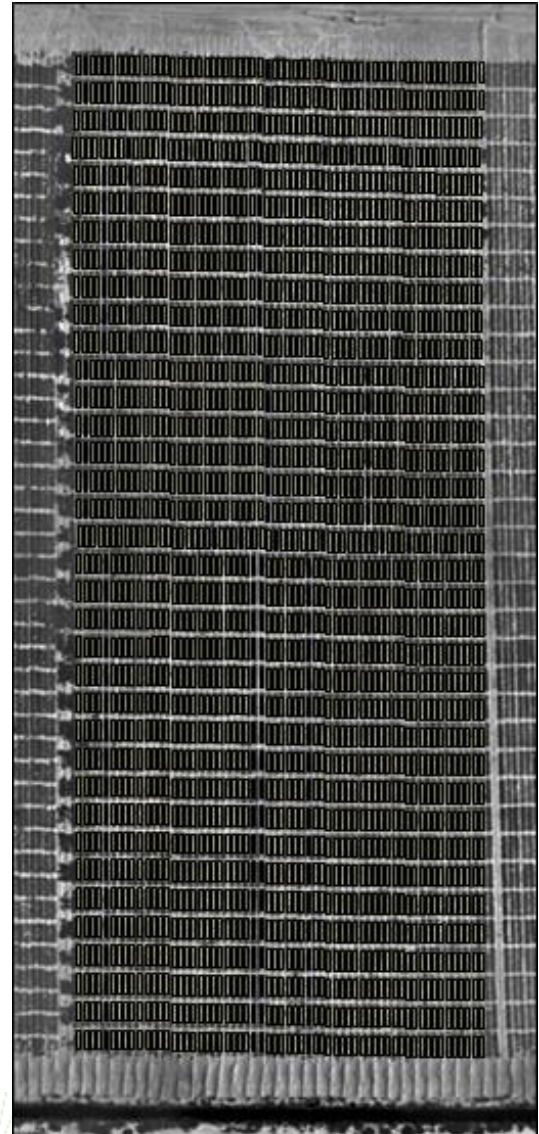
CIMMYT

Thermal imaging

- **Semi- automatic data processing:**
  - **Mosaics (Agisoft Photoscan)**
 - **Data Extraction (ArcMap + R)**

80% image overlap

Mosaics using Agisoft Photoscan

Data extraction per plot using polygons

Potentials of genomic selection

- **USAID Feed the Future Innovation Lab at KSU and DGGW focus on implementing GS and HTP at different stages of breeding program**

- **GBS, phenotypic, yield data for about 46,000 lines (2013-14 to 2017-18) utilized**

1st year yield trial (n=9940 in 2016-17 season)
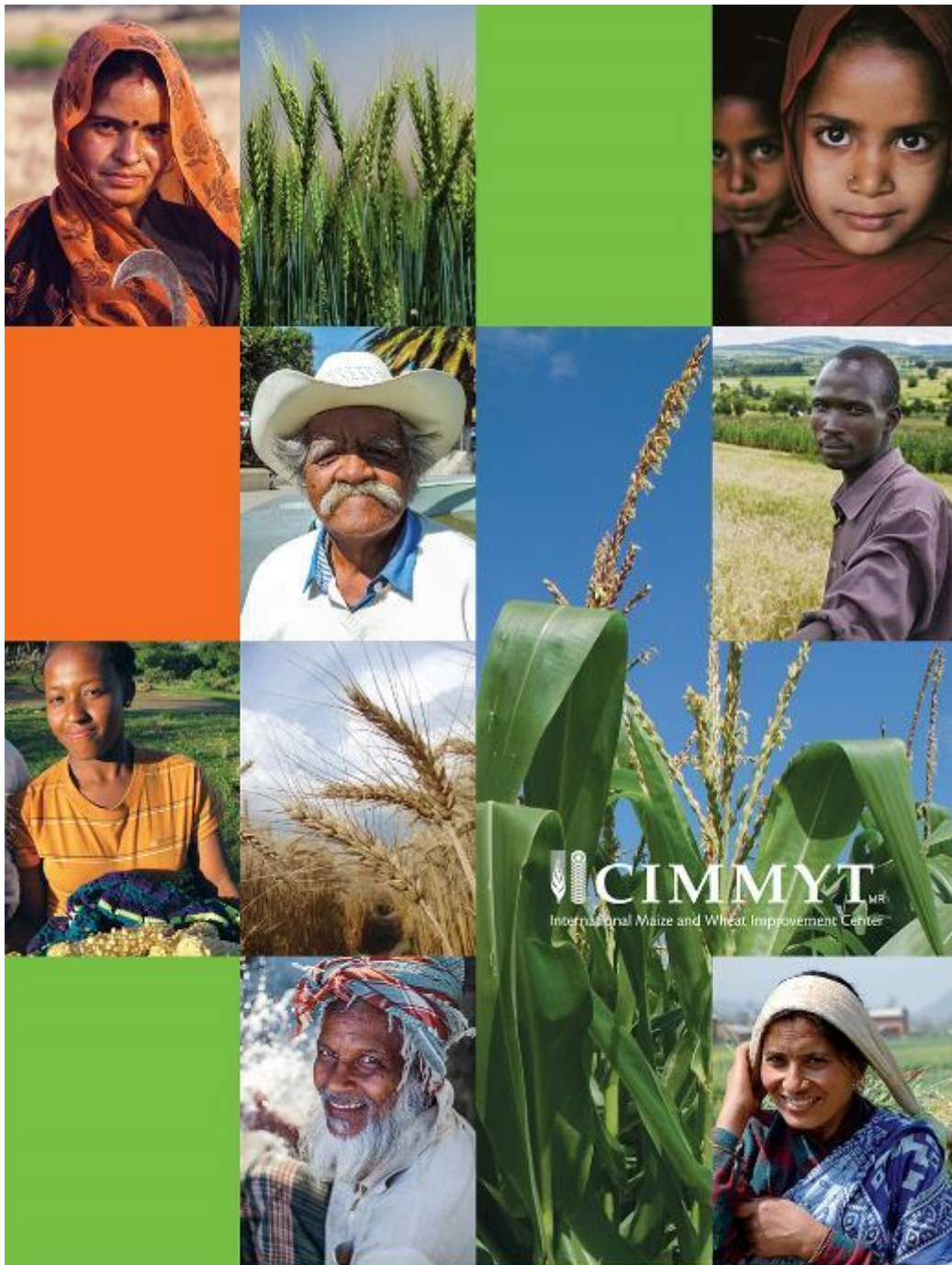
<15% retention rate
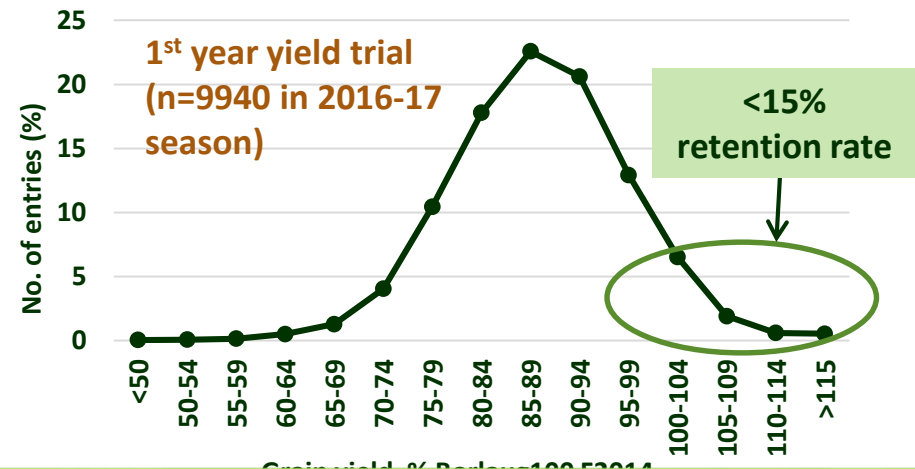
Genomic predictions are very promising for some diseases & quality traits. Challenges: G x E and G x Y interactions need extensive research to improve predictions for grain yields

1st year yield trials

- **Average within-nursery prediction accuracy Yield= 0.67, Stem rust=0.60**
- **Average across-nursery prediction accuracy Yield= 0.42, Stem rust=0.50**

2nd year yield trials, prediction accuracy (r)

	Within	Across	Within	Across	Within	Across	Within	Across	Within	Across
Grain yield	Bed 5IR		Flat 5IR		Bed 2IR		Flat drip		Late heat	
	0.59	0.15	0.60	0.05	0.59	0.14	0.59	0.09	0.60	0.17
Disease	Stem rust		FHB		S. tritici blotch		Spot blotch			
	0.79	0.60	0.38	0.11	0.57	0.17	0.55	0.24		
Quality	Alveogram W		Flour protein		Flour yield		Loaf volume		Mixing time	
	0.72	0.52	0.73	0.5	0.61	0.43	0.72	0.5	0.76	0.48

CIMMYT

Thank you for your interest!