Concept of yield levels and yield gaps

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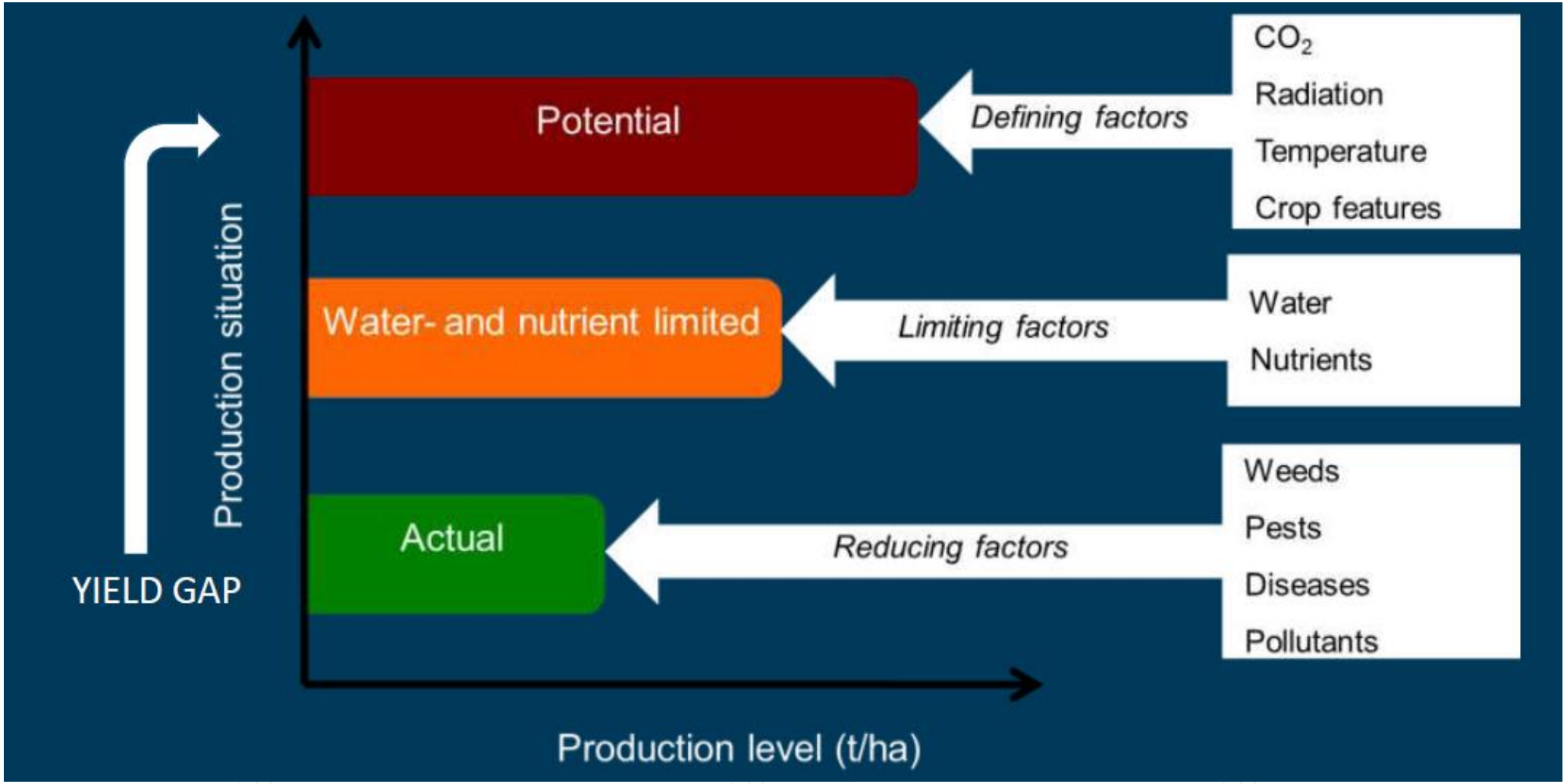
Production Ecological Principles, Yield Levels



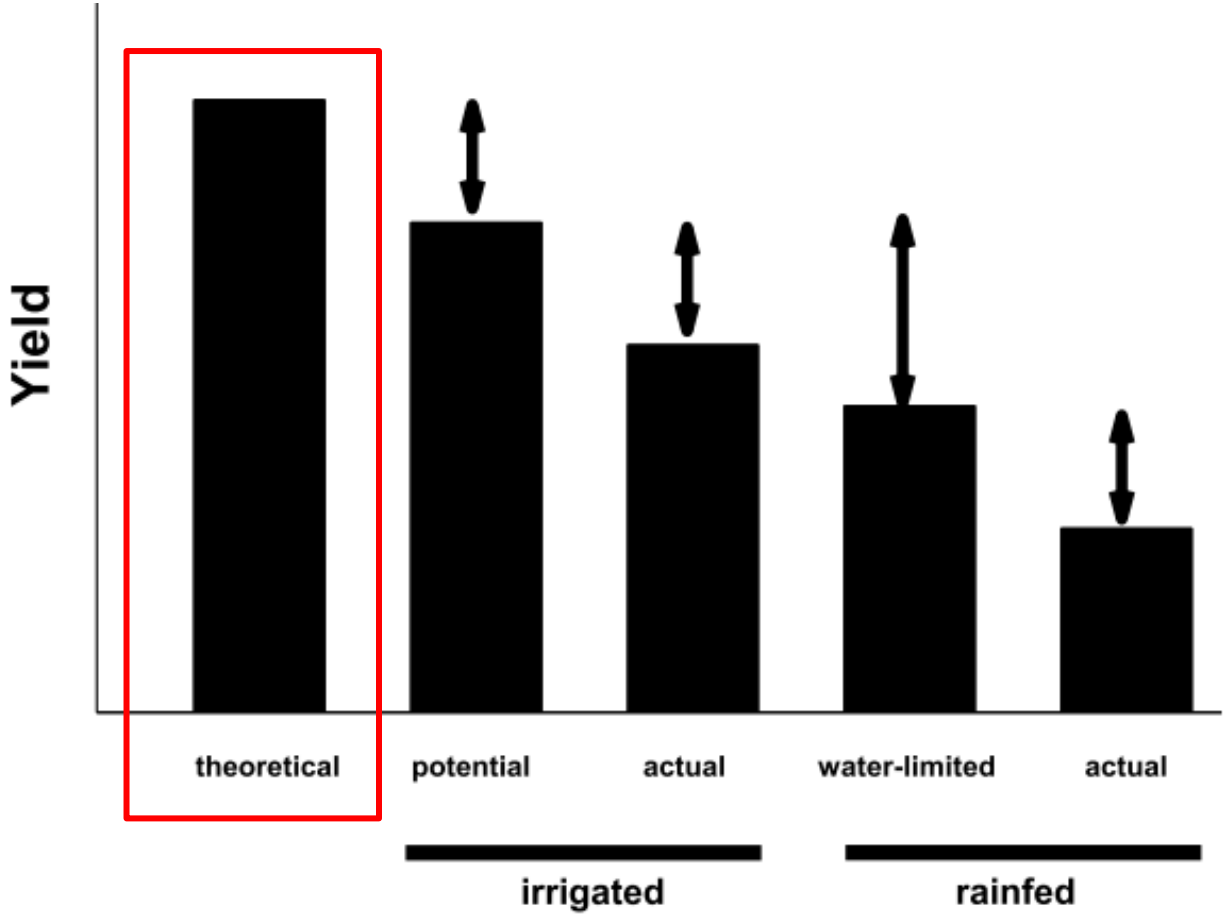
Lovenstein et al., 1995; Van Ittersum and Rabbinge, 1997; Van Ittersum et al., 2013

Definition of yield (Economic)

Theoretical yield

- is the maximum crop yield as determined by biophysical limits to key process including biomass production and partitioning. It can be estimated with crop models with sound physiological structure, and parameters reflecting the biophysical boundaries of key processes (Sadras *et al*., 2015)

- It is important for breeding programs.



Definition of yield (Economic)

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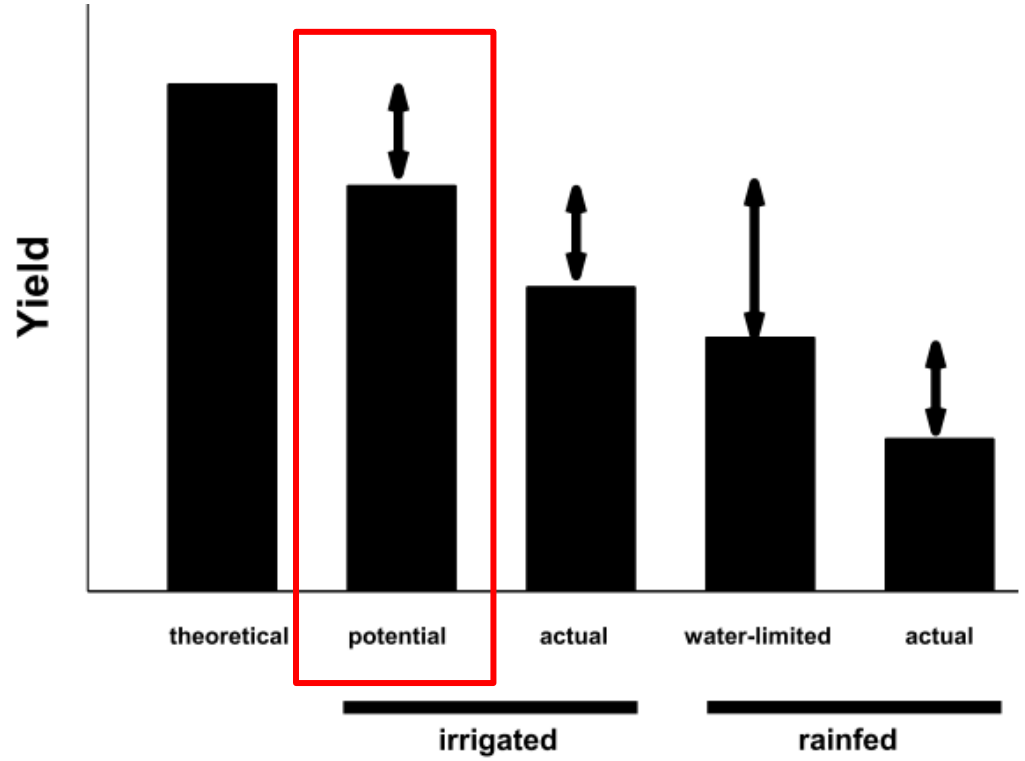
Potential yield (Yp)

- is the yield of a **current cultivar** when grown in environments to which **it is adapted**; with nutrients and water non-limiting; and with pests, diseases, weeds, lodging, and other stresses effectively controlled (Evans and Fischer 1999).
- It depends on the weather of the location but soil factors. The climate factors that influence potential yield are:
  - radiation, ambient CO_2 concentration, temperature, photosynthesis, vapor pressure deficit
- It is relevant to benchmark crops where irrigation, rainfall, or a combination of irrigation and rainfall ensure that water deficits do not constrain yield.



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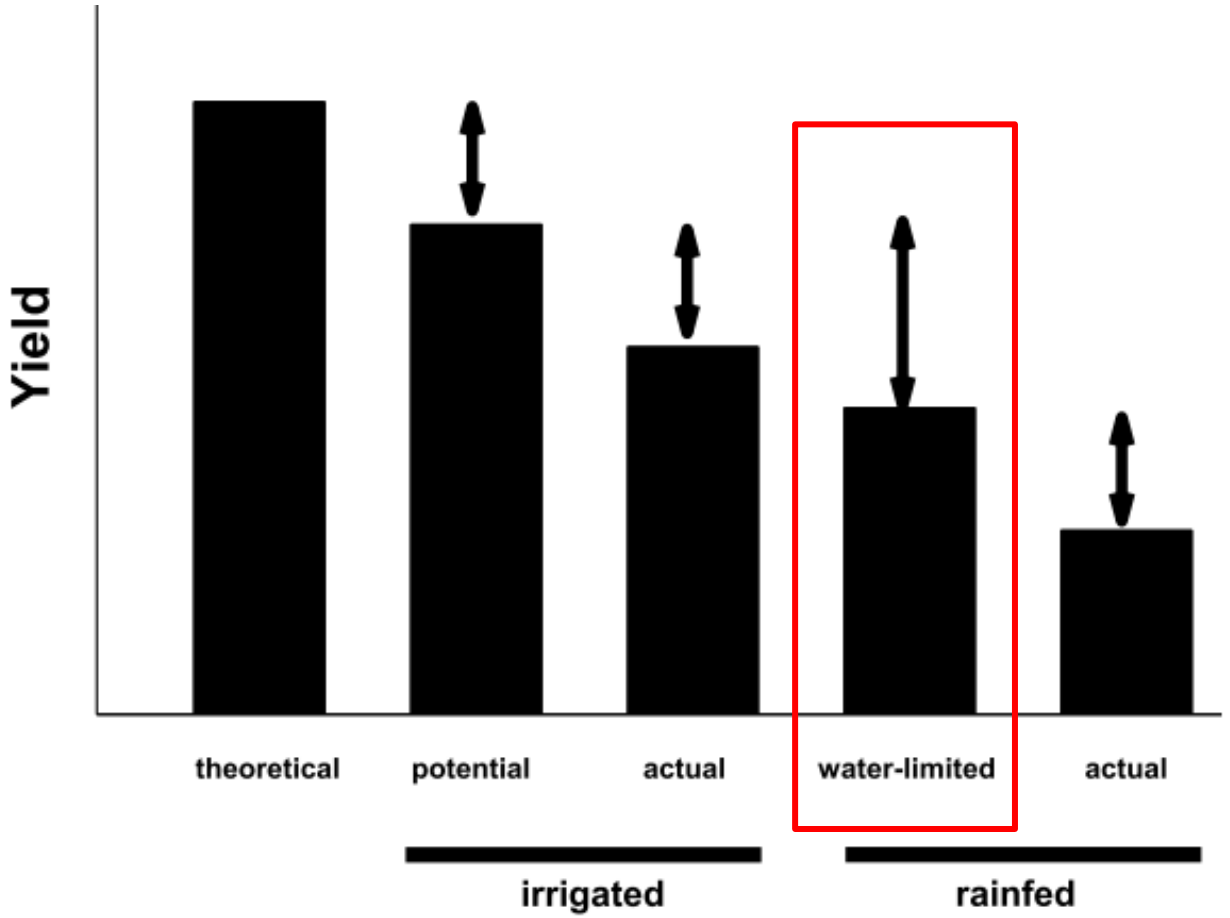
Definition of yield (Economic)…

Water-limited yield (Yw)

- similar to yield potential, except that yield is also limited by water supply, and hence influenced by soil type (water holding capacity and rooting depth) and field topography.

- This measure of yield is relevant to benchmark rainfed crops.

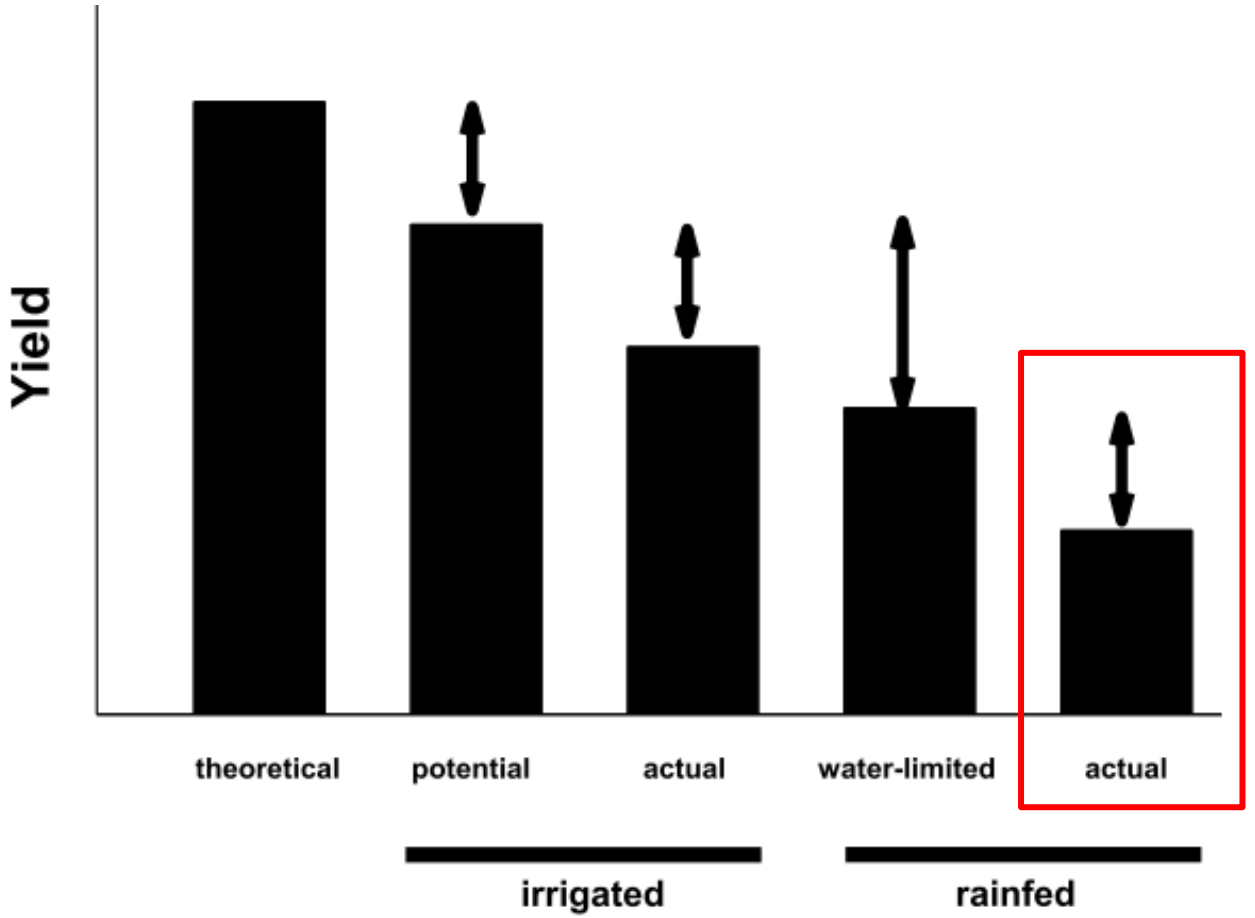


Definition of yield (Economic)…

Actual yield (Ya)

- reflects the current state of soils and climate, average skills of the farmers, and their average use of technology.

- This measure of yield is relevant to benchmark farmers yields.

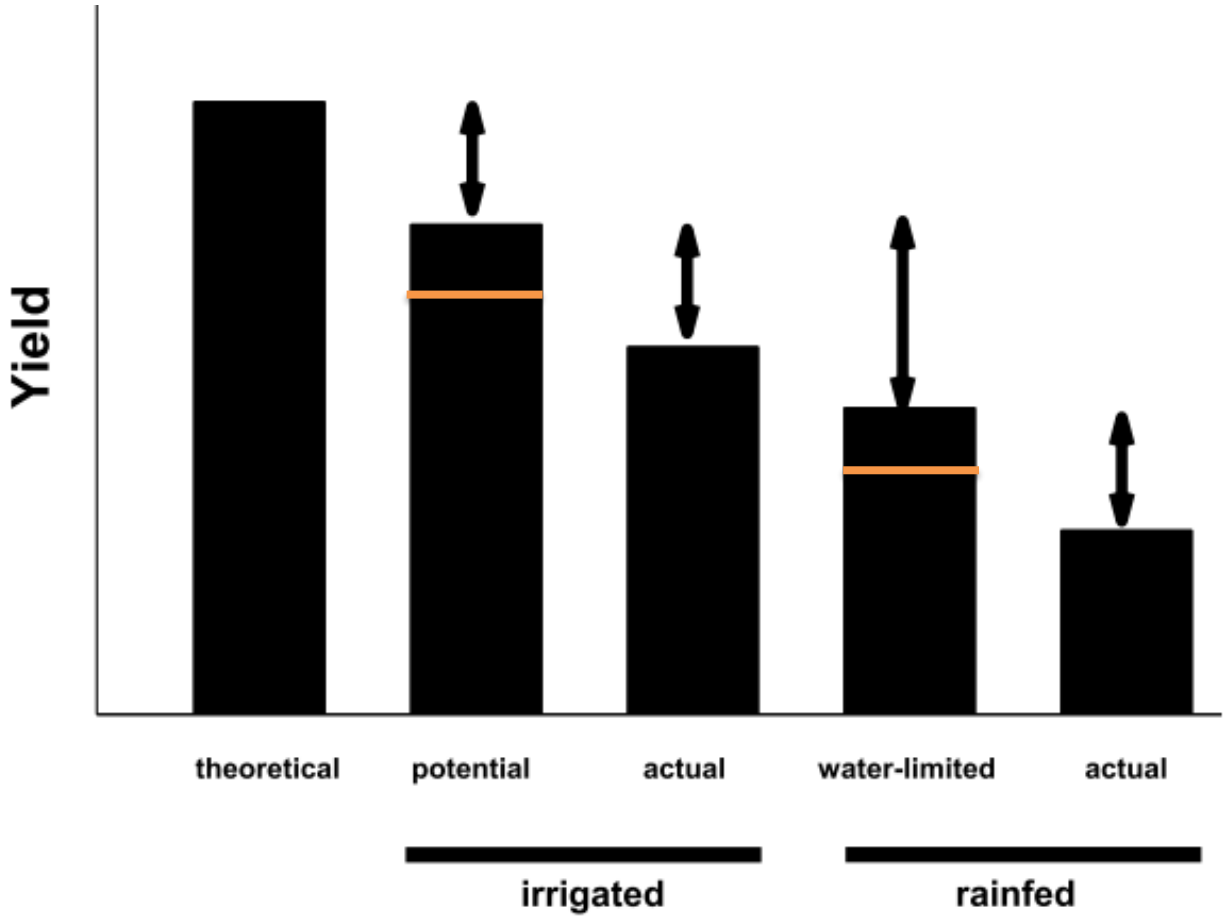


Definition of yield …

Attainable yield (Yat)

- is the best yield achieved through skillful use of the best available technology. Some studies use attainable yield as 70-80% of either potential yield or water-limited yield (Hall et al. 2013; Van Ittersum et al., 2013).

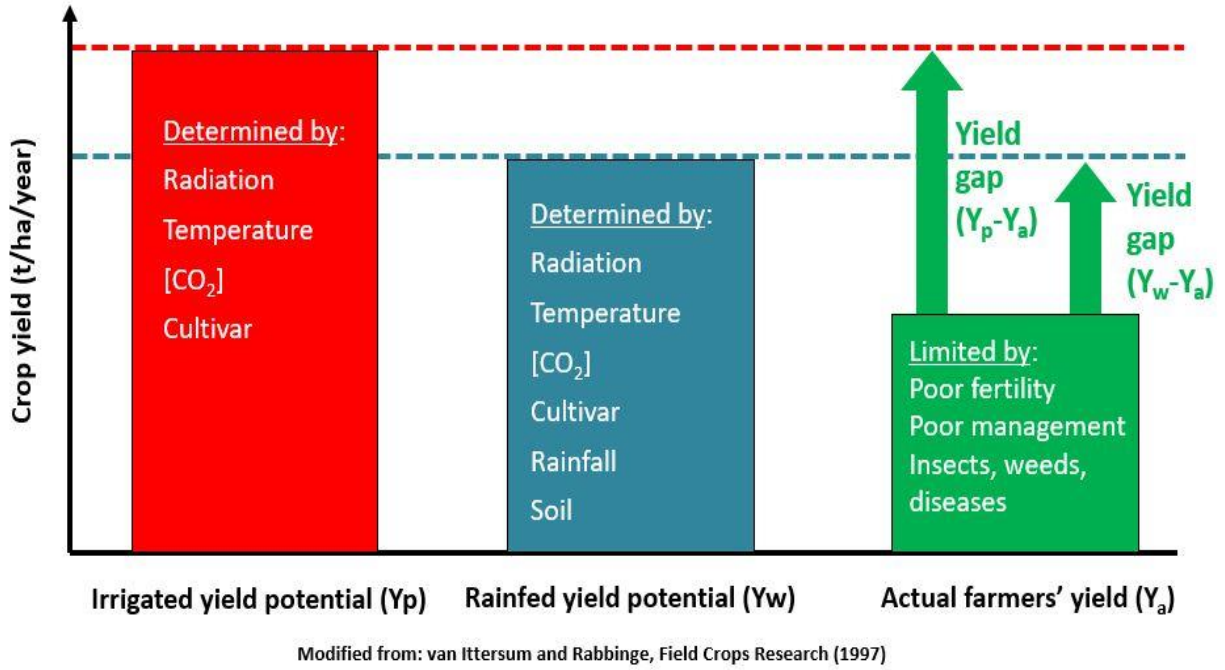
- This measure of yield is relevant to benchmark research-station yields.



Yield Gaps

Yield gap is the difference between two levels of yield. Depending on the objectives of the study, different yield gaps are relevant.

- Potential yield gap = **Yp - Ya**
- Water limited yield gap = **Yw - Ya**
- Attainable yield gap = **Yw(70%) - Ya**



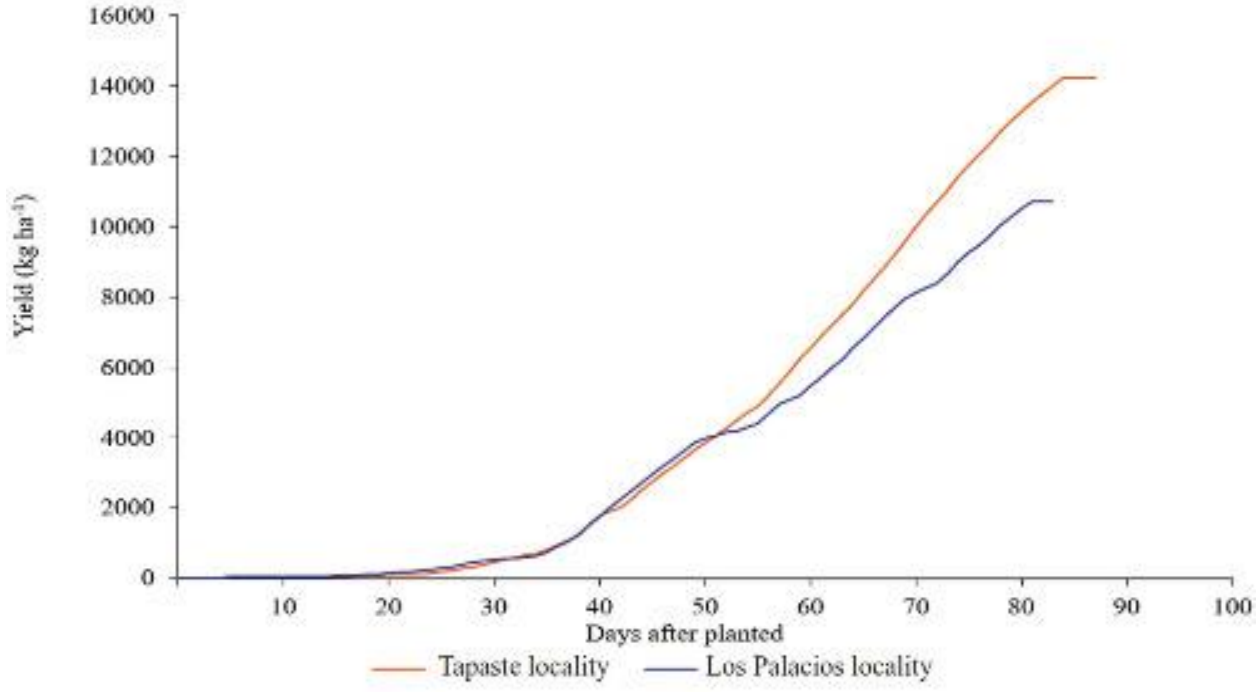
Modified from: van Ittersum and Rabbinge, Field Crops Research (1997)

https://www.yieldgap.org/

Yield measurements and estimation of yield gaps

Potential yield measurement

- Estimated using crop models (e.g., DSSAT, APSIM, WOFOST, etc.) under non-limiting conditions for specific varieties and climatic conditions.
- Simulations can be done over several years and locations

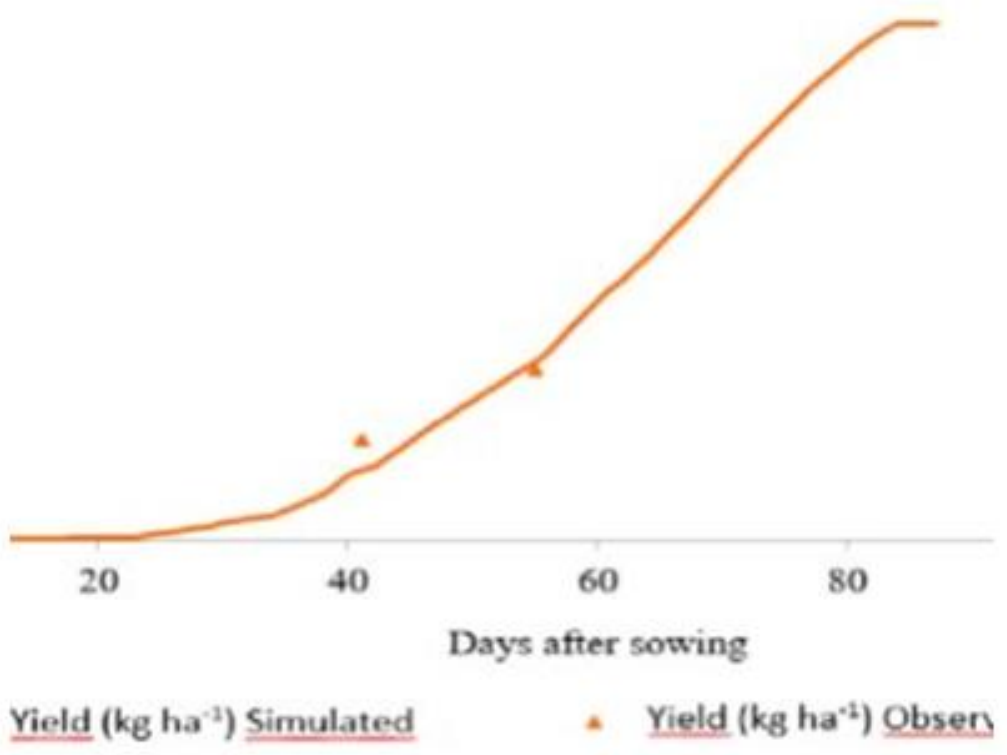


González et al. 2020

Yield measurements and estimation of yield gaps

Water limited /rainfed yield measurement

- Estimated using crop models (e.g., DSSAT, APSIM, WOFOST, etc.) under **water-limited conditions** for specific varieties and climatic conditions.
- Simulations can be done over several years and locations .



Yield measurements and estimation of yield gaps

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Attainable yield measurement

- Can be measured from well controlled experiments on research stations (non-limiting nutrients and pests and disease controlled).
- Can be taken as the average of an adapted crop variety yield over years
- **Limitation** – mostly difficult to control nutrient and pest constrains

Actual yield measurement

- Estimated from farmers plots through surveys and crop cuts
- Maximum, minimum and average yields
- Aggregation can be at plot, sub-national or national level.
- Represents a combination of factors (water, nutrient, pest and management factors

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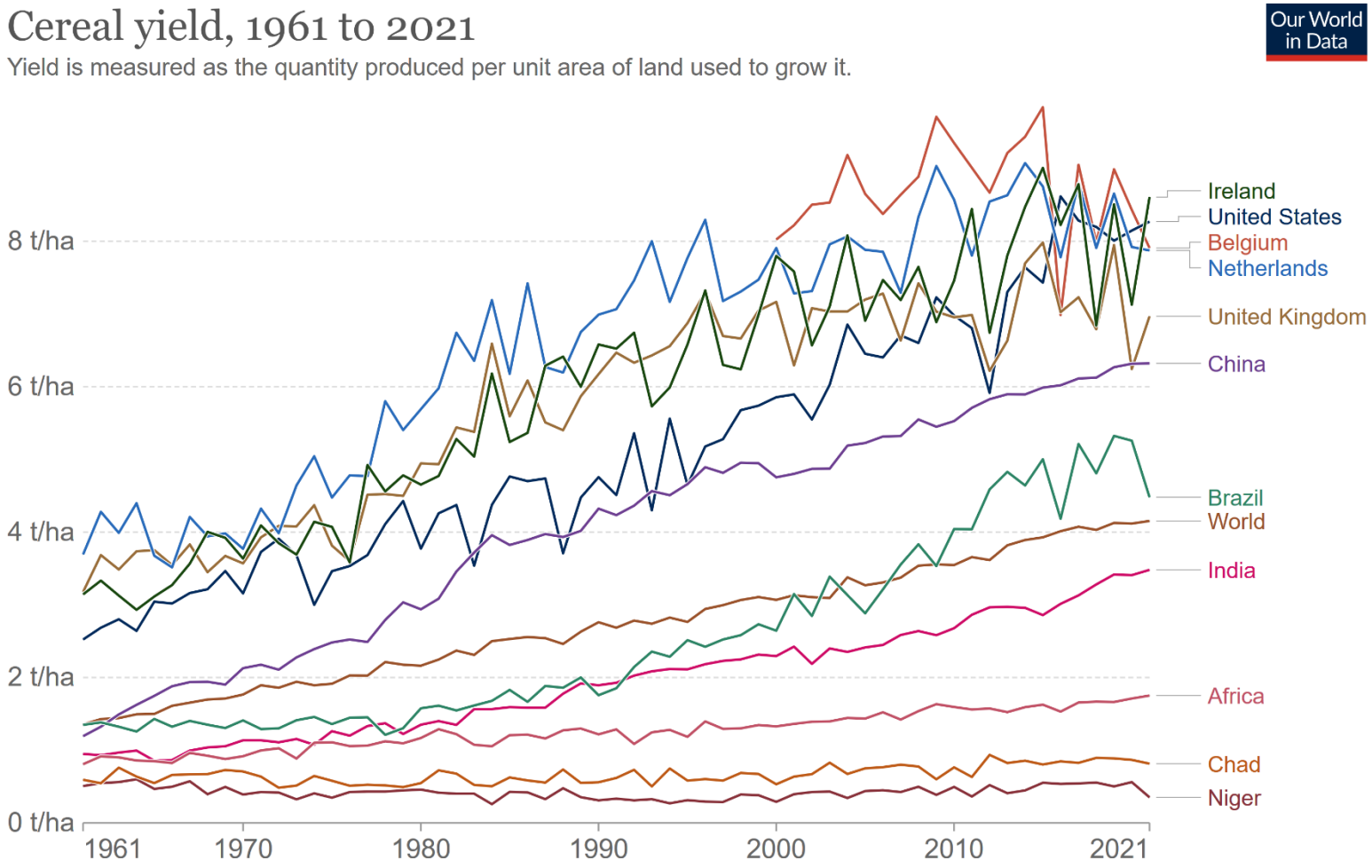
Actual yields at national global, regional and national levels- Yield trends



Actual yields at national global, regional and national levels- continental average yields

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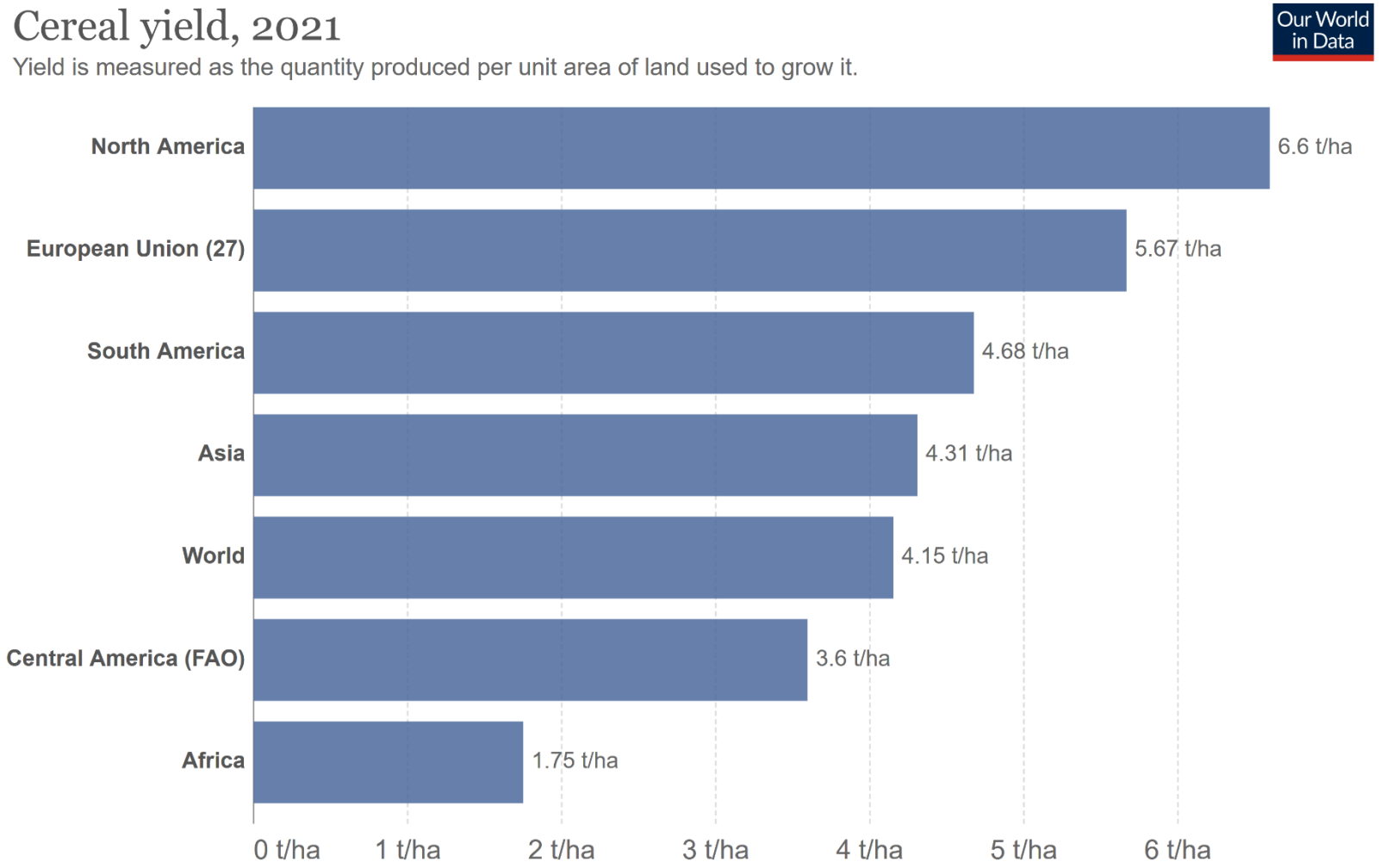

Source: UN Food and Agriculture Organization (FAO)
Note: Cereals include wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat, and mixed grains.

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Actual yields at national global, regional and national levels-

Sub-regional average yields

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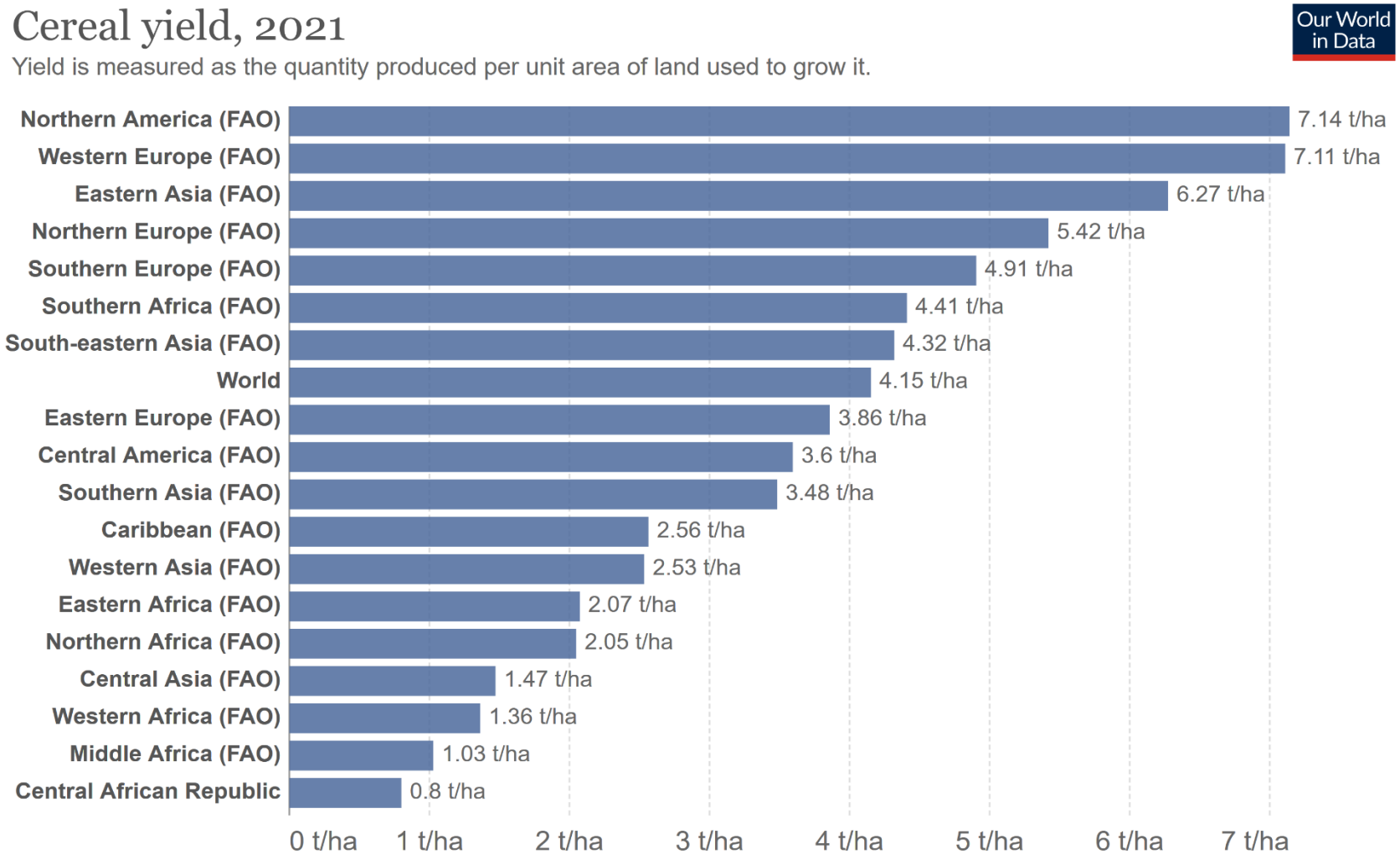

Source: UN Food and Agriculture Organization (FAO)
Note: Cereals include wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat, and mixed grains.

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Actual yields at national global, regional and national levels- average yields across income levels

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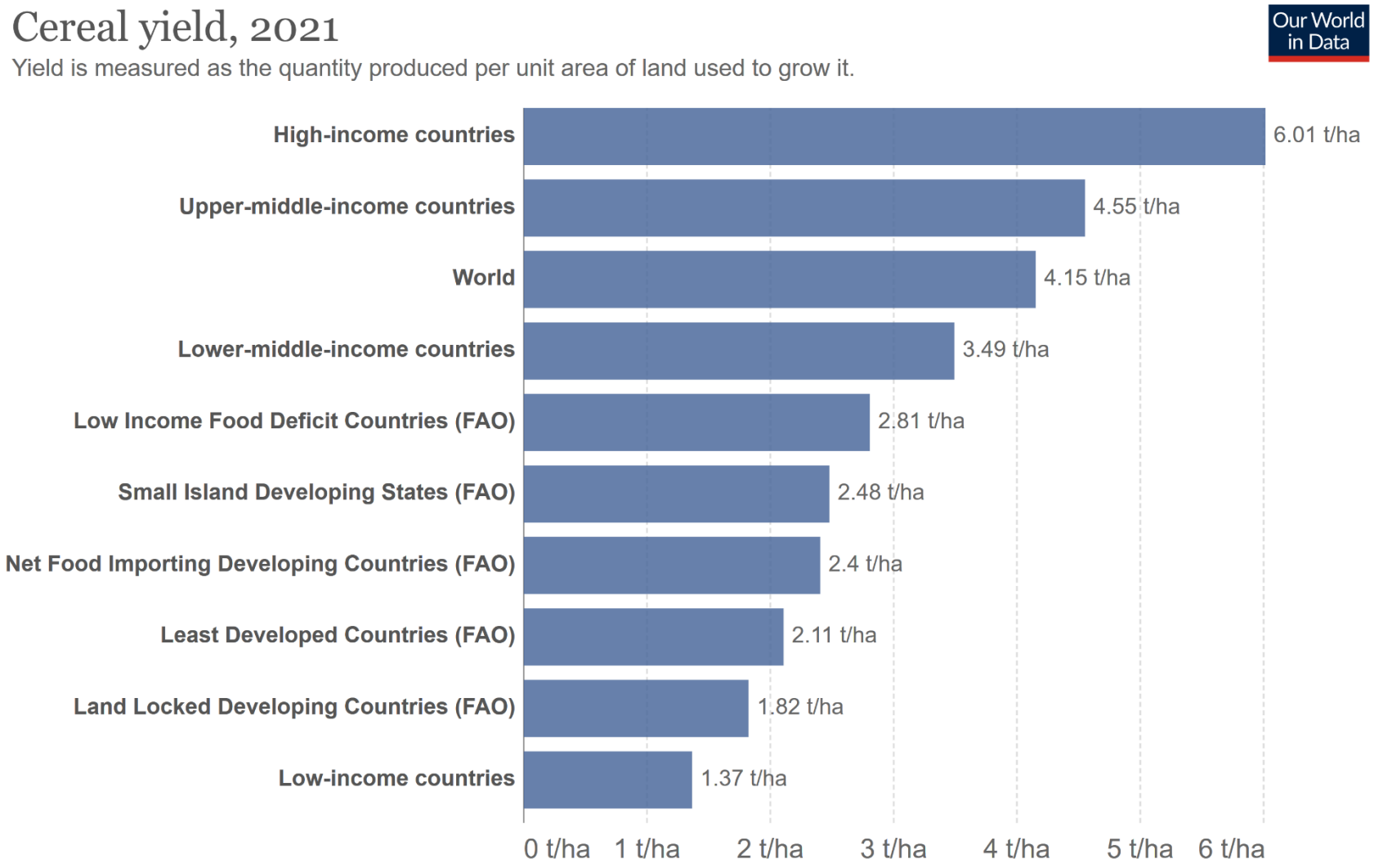

Source: UN Food and Agriculture Organization (FAO)
Note: Cereals include wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat, and mixed grains.

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Actual yields at national global, regional and national levels- average national yields

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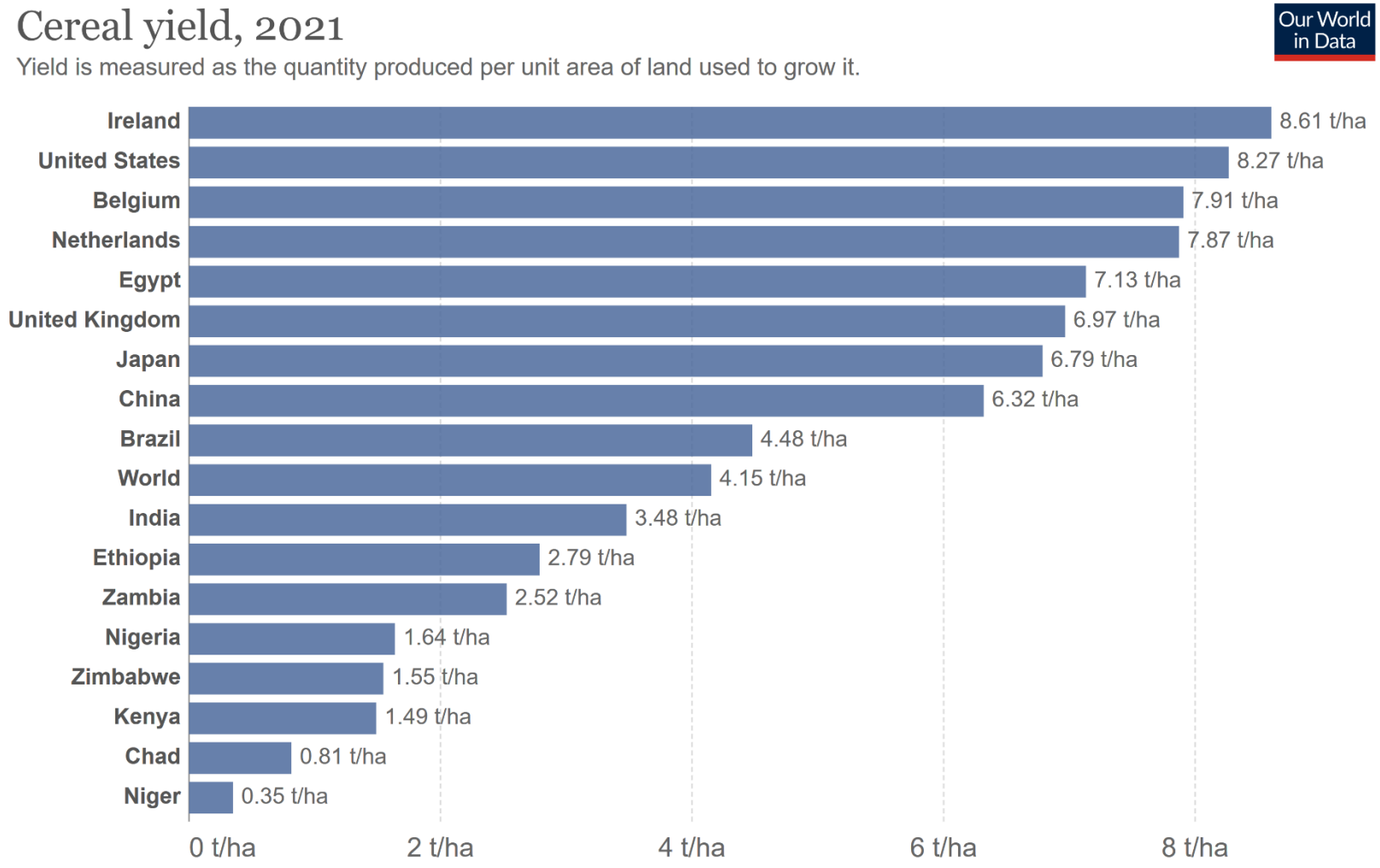

Source: UN Food and Agriculture Organization (FAO)
Note: Cereals include wheat, rice, maize, barley, oats, rye, millet, sorghum, buckwheat, and mixed grains.

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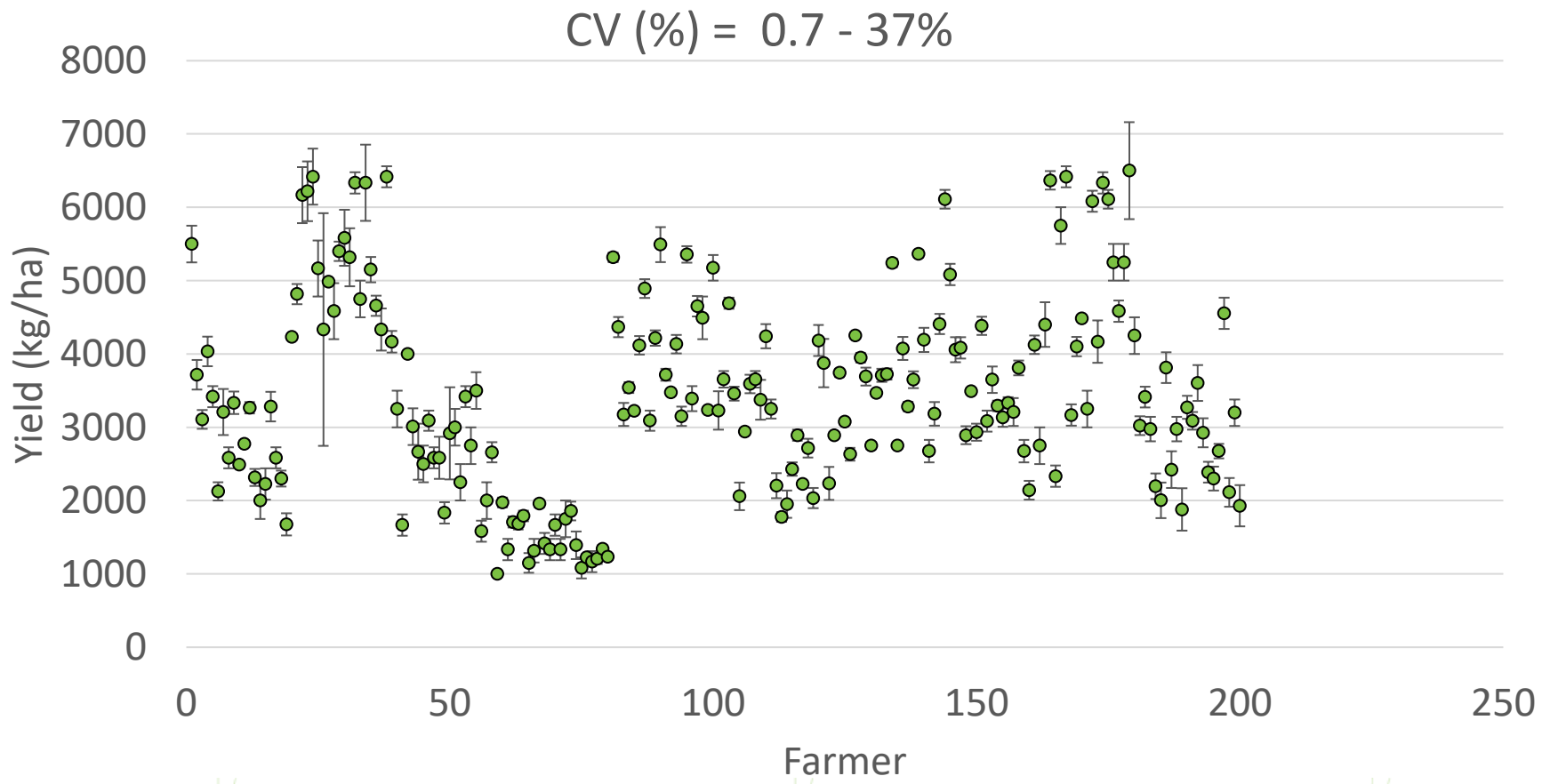
Actual yields at Plot Level- average plot level yields in a district (wheat)



Spatial and temporal scale of yield gap estimation

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- Yield gaps can be quantified at different scales in space and time (Hall et al. 2013).

- The accuracy and precision of basic data for yield gap analysis need to be considered in relation to the target spatial and temporal scale.

- Spatially, yield gaps have been quantified at different levels
  - Field
  - Region
  - national or
  - mega-environment
  - globally .
- Variation of yield within fields is the focus of site-specific management.
- Little attempt has been made to capture within-field variation in yield gap analysis.

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Scale of Yield Gap Estimation

Yield gap studies so far:

- Some do not make explicit assumptions about time scale,
- some have explicitly used time series that are long enough to span a wide weather range but short enough to meet the assumption of constant technology, and
- some have explicitly used time series to characterize time-trends in yield gaps.

Why we study yield gaps

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Realistic solutions are required to close yield gaps in both small and large-scale cropping systems world-wide.

1. Definitions and techniques tare needed to measure and model yield at different levels (actual, attainable, potential) and different scales in space (field, farm, region, global) and time (short, long term)
2. Identification of the causes of gaps between yield levels.
3. Assessing management options to reduce the gaps where feasible.
4. Suggest policies to favor adoption of gap-closing technologies.

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Questions, Comments ???

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Group Discussion

- What are your experiences in working with farmers in observing yield gaps?

- Do you think that yield decomposition helps you in your work (use case)? If so, in what way? If not, why?

- Which **Yield Gap Decomposition** methods do you think works for you? Why?

Thank you for your interest!