The role of plant breeding for increasing productivity and reducing crop losses

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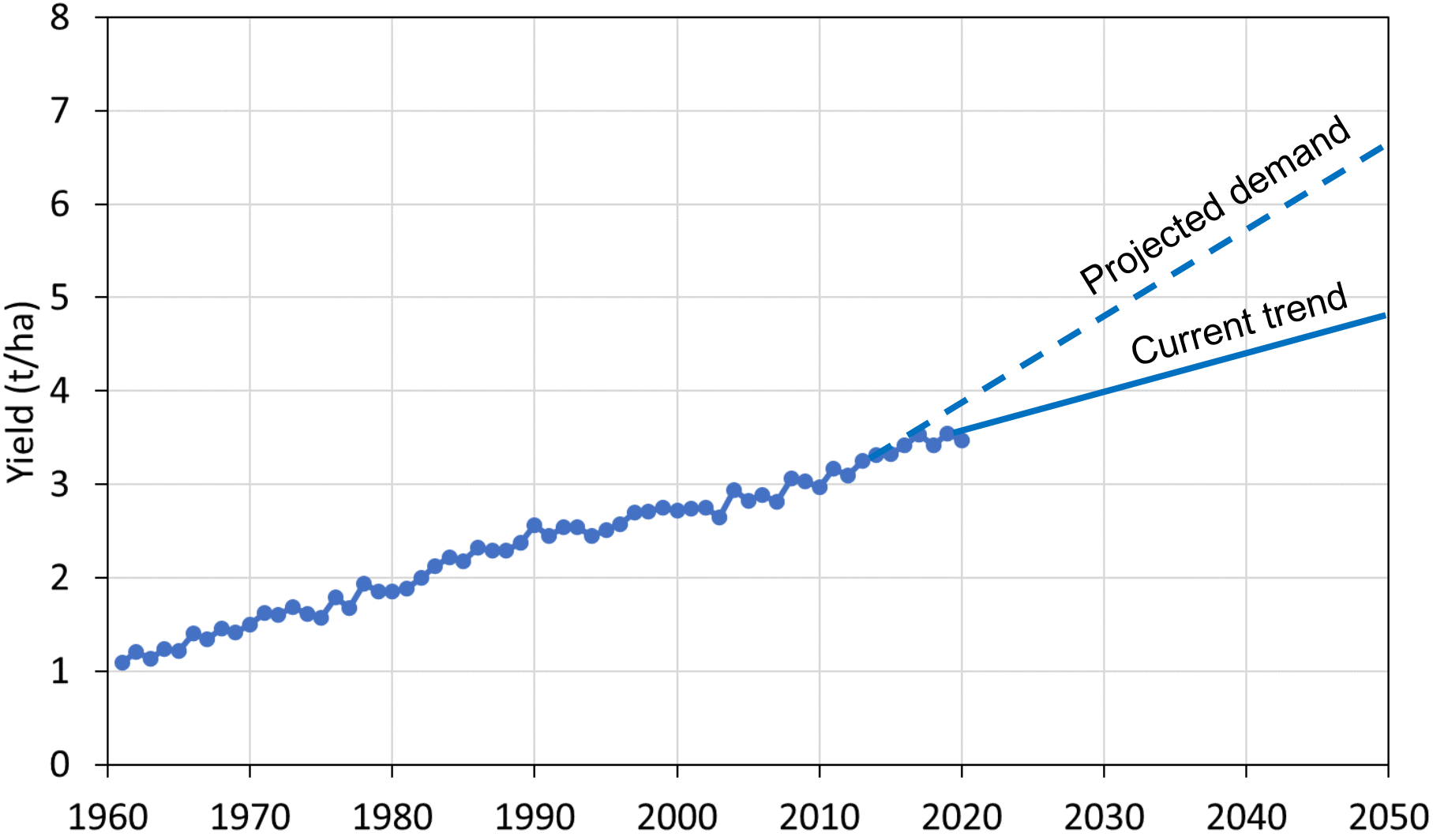
Actual and projected global wheat yields



Adapted from Long et al, (2015) Cell 161:56-66

How to reduce the climate footprint of crop production?

Outline

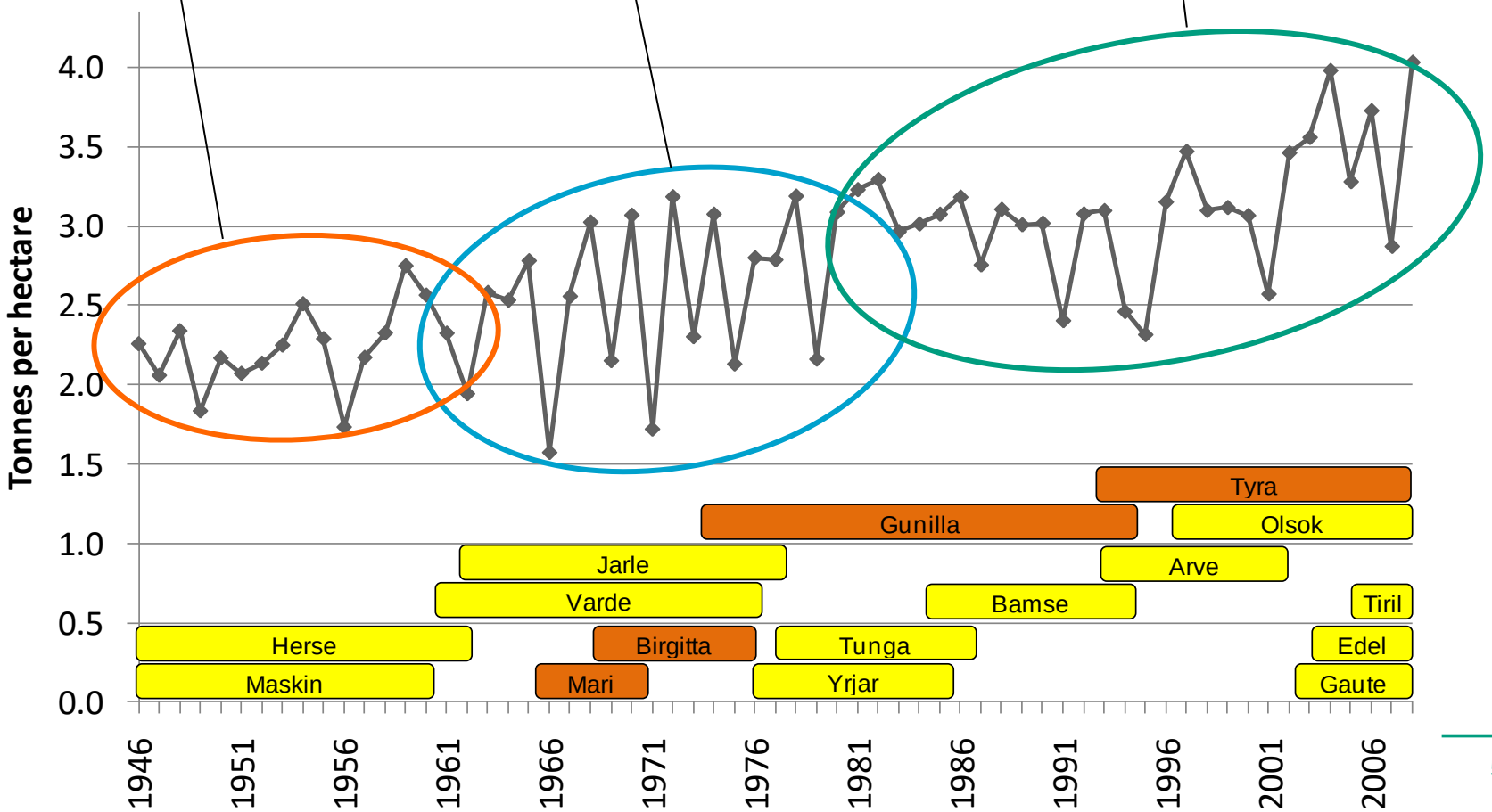
- Impacts of plant breeding for improving yield
  - Case 1: Barley yields in central Norway
  - Case 2: Yield genetic gains in wheat
- Impacts of plant breeding for reducing crop lossess
  - Case 3: Fusarium head blight resistance in wheat

Barley yields in central Norway

1946-1960:
”The self-binder era”
Few new varieties and little yield increase

1960-1980:
”The first combine era”
Difficult harvest conditons and unstable yields

1980-2008:
”The modern varieties era”
New and better adapted varieties



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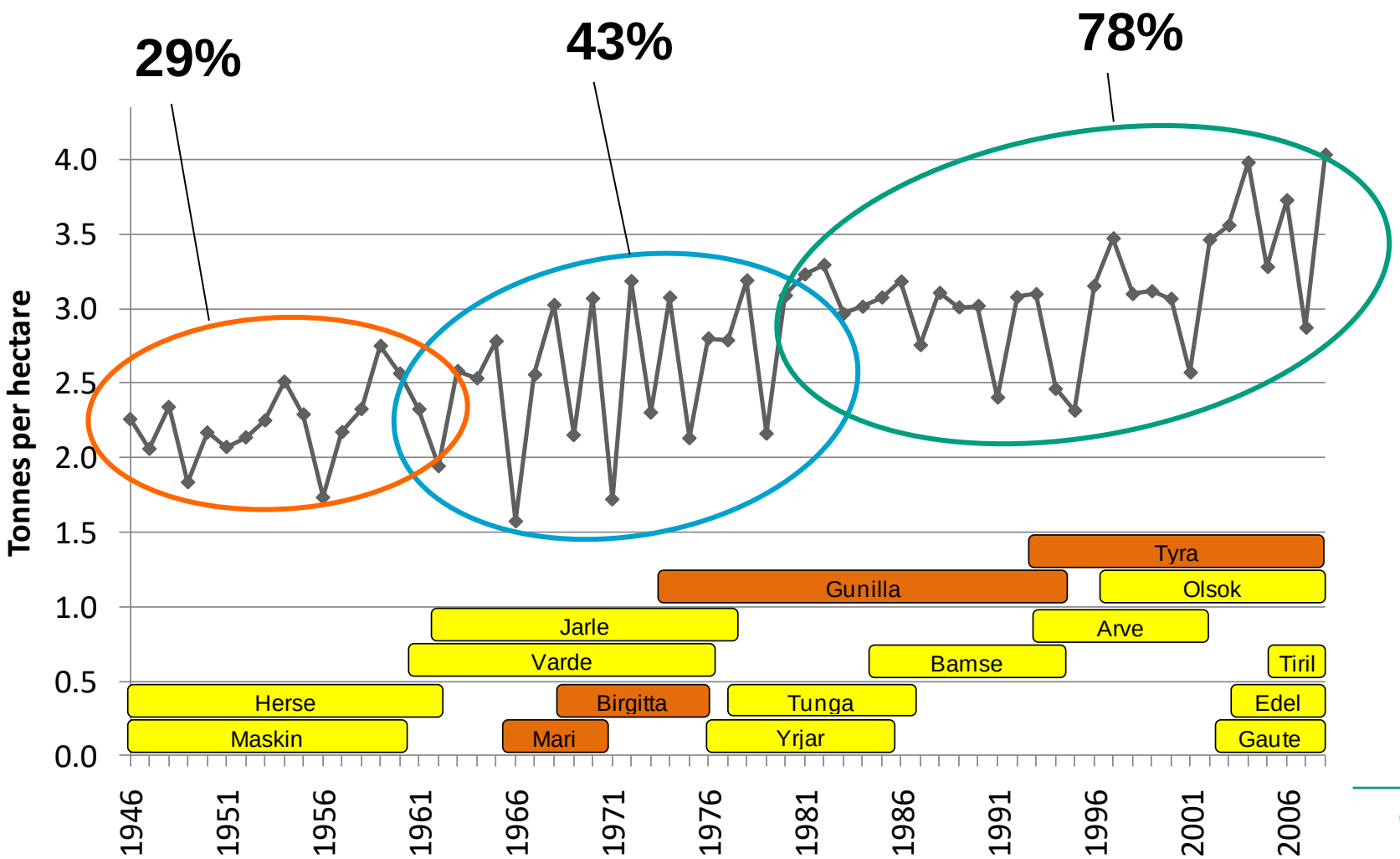

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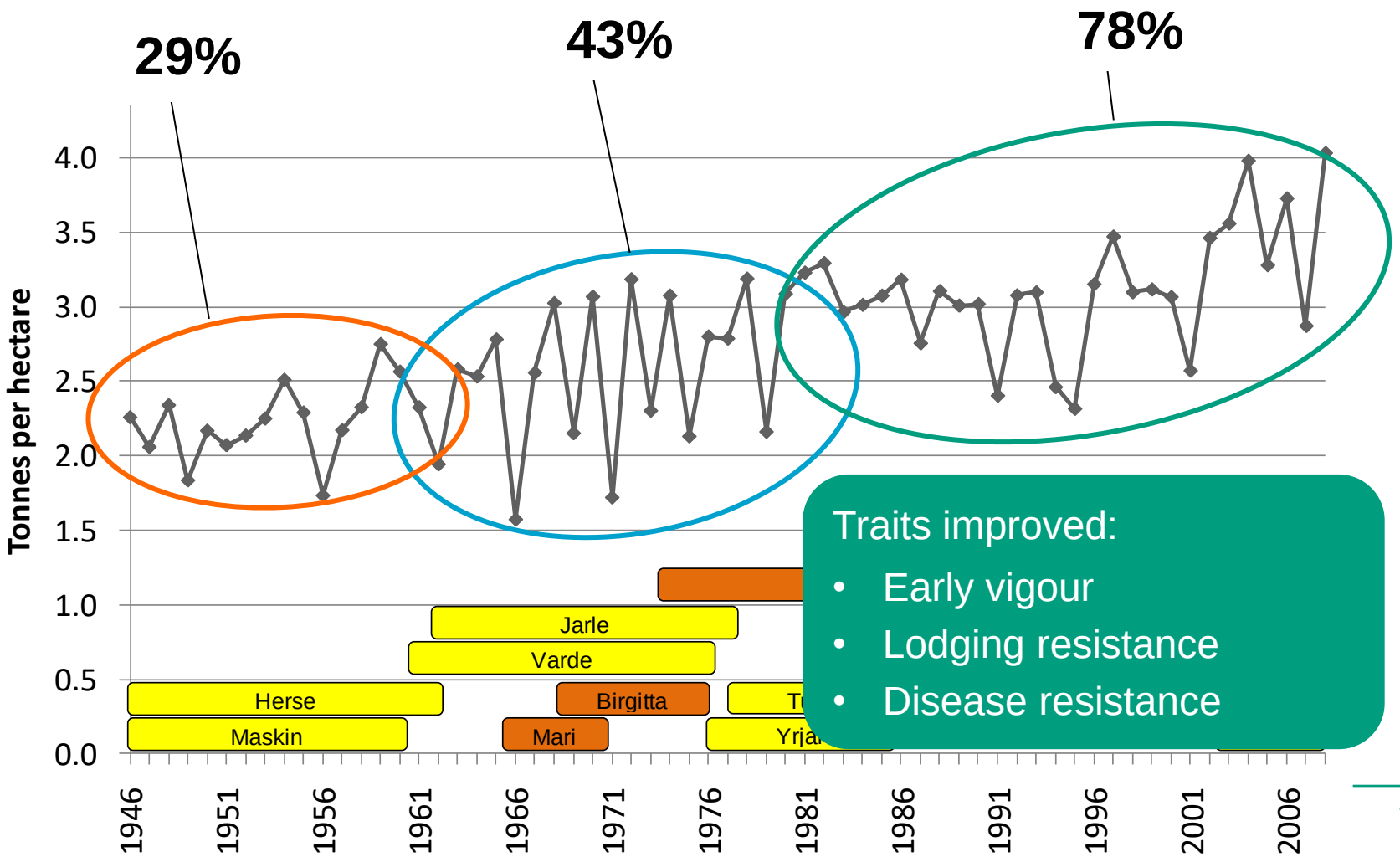


Traits improved:

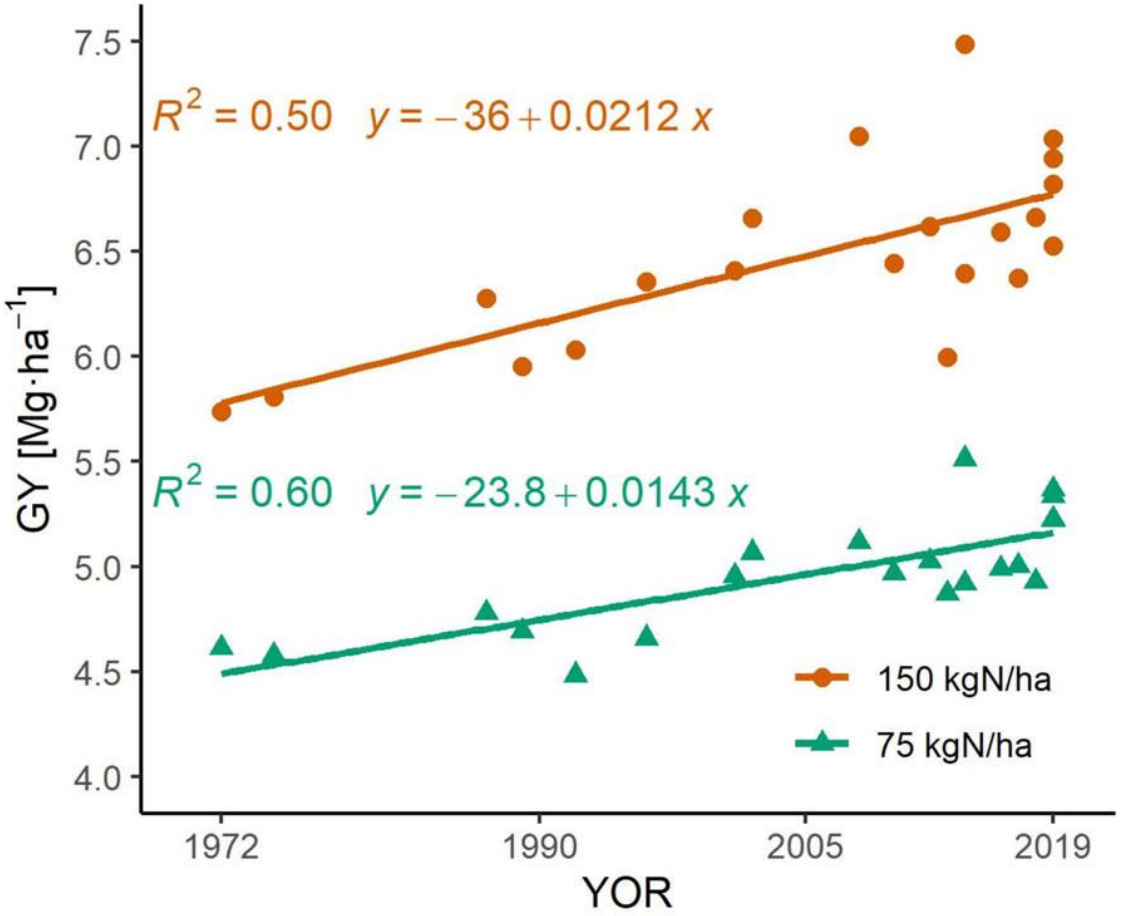
- Early vigour
- Lodging resistance
- Disease resistance

Yield genetic gains in Norwegian spring wheat

- Yield trials with 19 varieties released during the period 1972-2019
- Two nitrogen fertlization levels:
  - 150 kg N/ha and 75 kg N/ha

Mróz et al (2022),
Crop Science 62: 997-1010
https://doi.org/10.1002/csc2.20714

Genetic improvement of 1 t/ha



- Similar yield gains at both N-fertilization levels
- Modern varieties at low input approach the yields of old varieties at high input

Mróz et al (2022),
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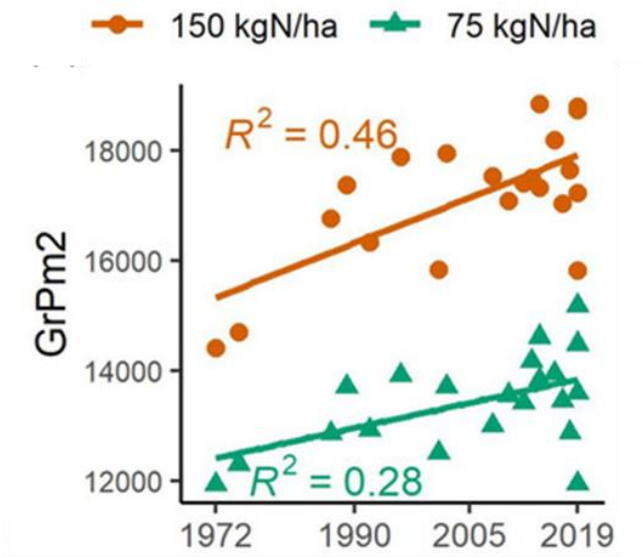
Which traits were improved?



- More grains per head and per m^2
  - producing more grains with the same available resources

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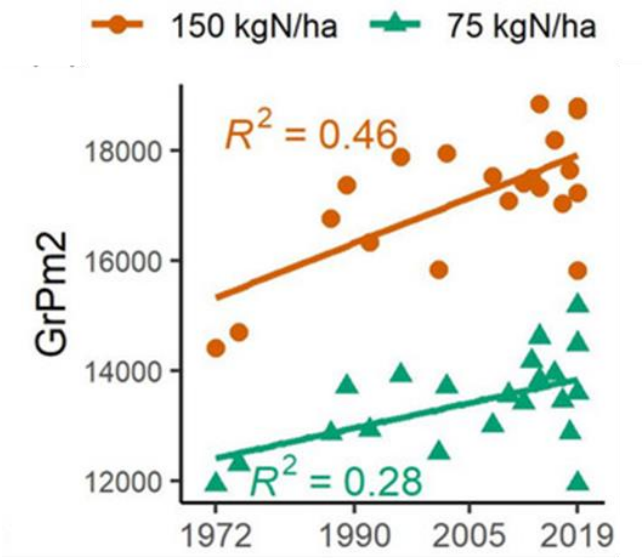

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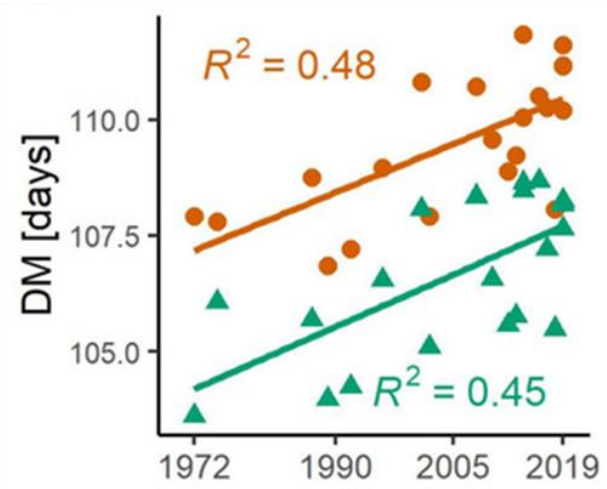

- Later maturity (~ 3 days)
  - Better utilization of the longer growing season

Mróz et al (2022),
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Fusarium Head Blight (FHB)

- A major disease problem on all cereals in Norway since the 1990s
  - reduced tillage, inadequate crop rotation, cultivation of susceptible cultivars
- Caused by *Fusarium graminearum* and other Fusarium pathogens
- Accumulation of mycotoxins in the grains

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- Caused by *Fusarium graminearum* and other Fusarium pathogens
- Accumulation of mycotoxins in the grains
- No easy solution:
  - no fully effective fungicides available
  - no cultivars with complete resistance
- A good case for integrated disease control

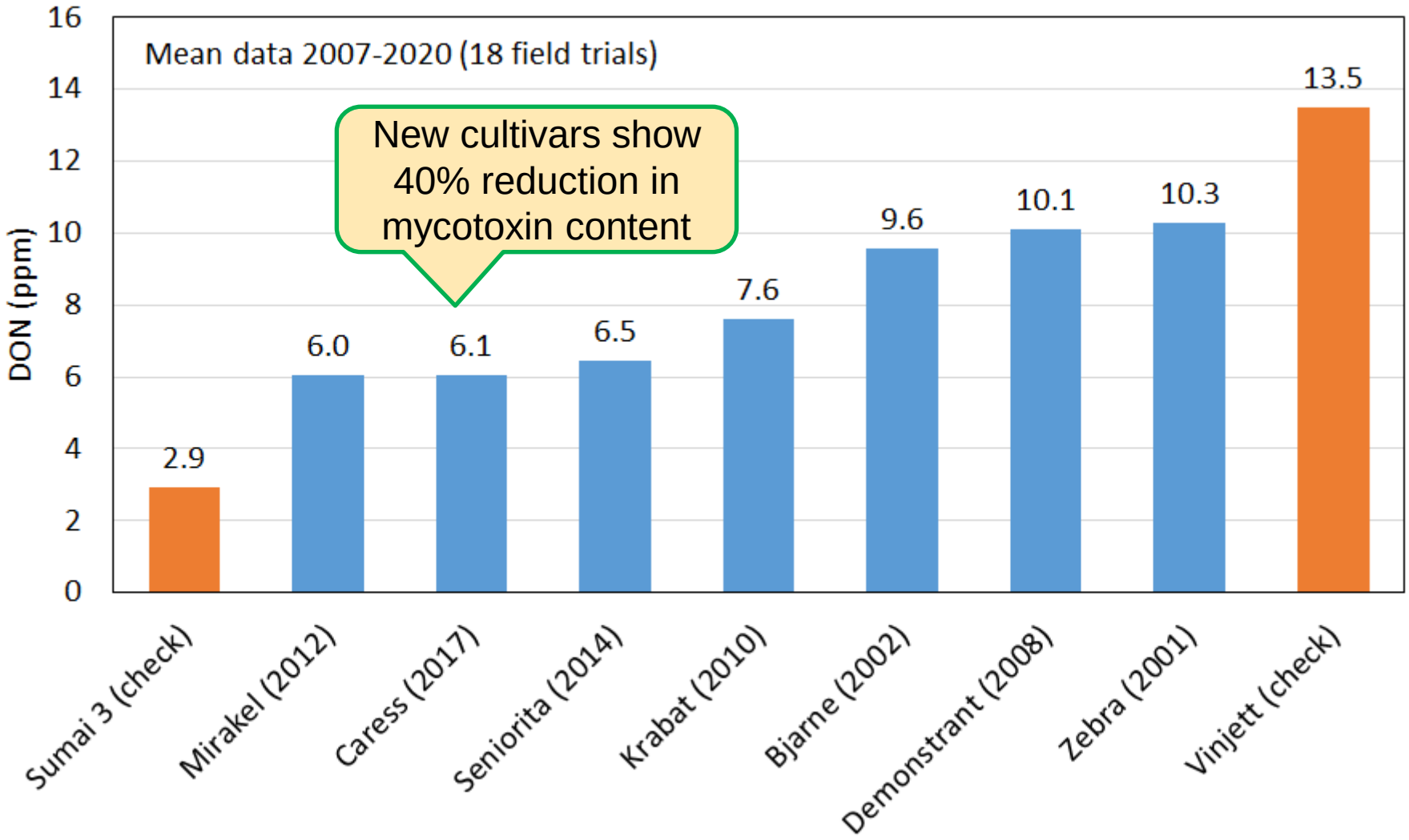
Components of FHB resistance

Active resistance	Evaluation
Type I: Resistance to invasion	Severity after spray/spawn inoculation
Type II: Resistance to spread	Severity after point inoculation
Type III: Mycotoxin accumulation	DON content
Type IV: Kernel infection	% FDK
Type V: Tolerance	Yield

We need a good genetic understanding of these traits

Passive resistance (avoidance)
Increased plant height
Flowering biology: anther extrusion, cleistogamy, flower opening, etc.

Progress in breeding for FHB resistance in spring wheat



Summary

- Plant breeding works!
- Increased productivity
  - Case 1: Yield stability of barley cultivars – better adapted to new harvesting regime
  - Case 2: Higher-yielding spring wheat cultivars with better nitrogen utilization
- Reduced crop losses due to disease
  - Case 3: New cultivars with 40% reduction in mycotoxin content

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