New technologies in cereal breeding and how they will affect crop production in the medium to long term

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New technologies in cereal breeding and how they will affect crop production in the medium to long term

- Breeding Objectives
- External factors influencing priorities
- Breeding Systems
- New techniques
- Genotyping & Phenotyping
- Key trait examples

Breeding Objectives

Grower requirements

- Consistency of yield and quality
- Ease of production
- Marketable product
- High quality technical advice

End User requirements

- Reliable quality
- Consistent supply
- Ease of processing
- Economically sourced

External Factors affecting Breeding

Environment

- Seasonal variability/unpredictability
- Frequency & severity of epidemics
- Sub-optimal timing for inputs

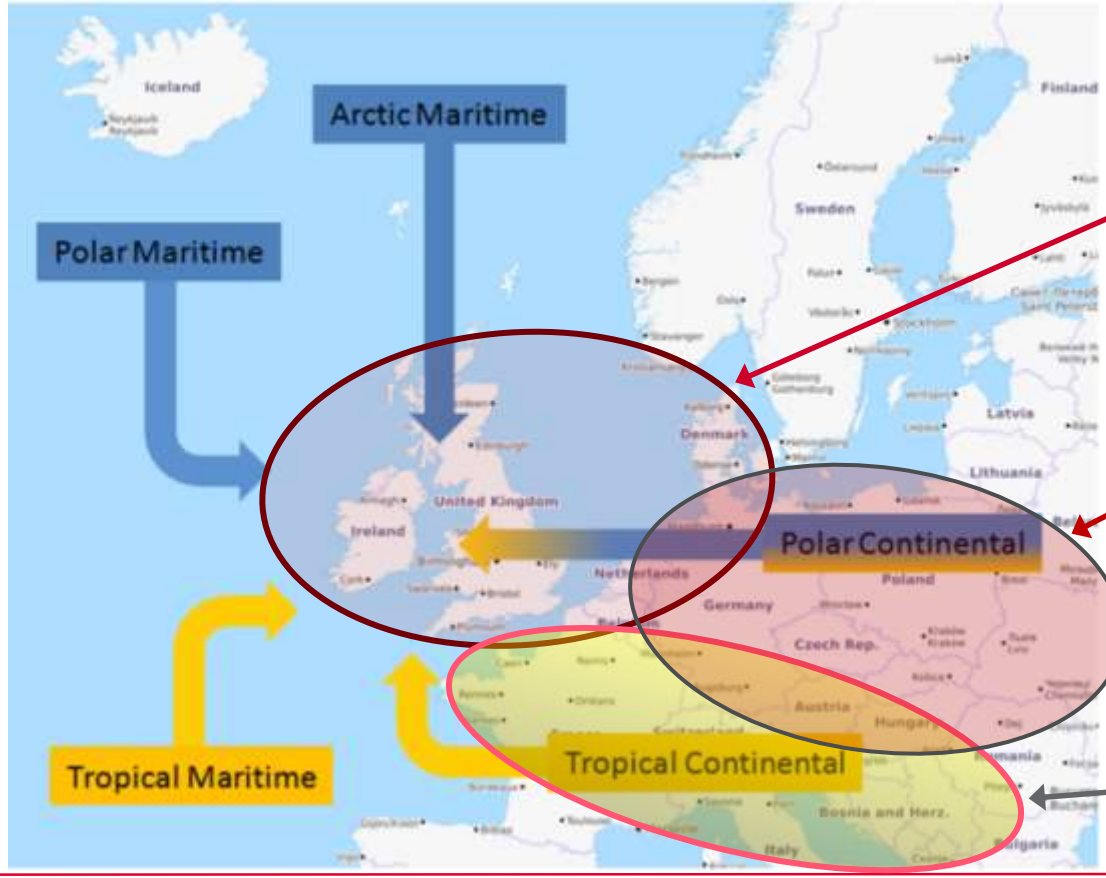
Technology

- Precision Agriculture
- End user processes or new markets
- Novel breeding technology

Legislation

- Food quality regulations
- Agrochemical withdrawal
- Nitrate sensitivity
- New breeding techniques (GE or GM)

Adaptation zones for European Wheat

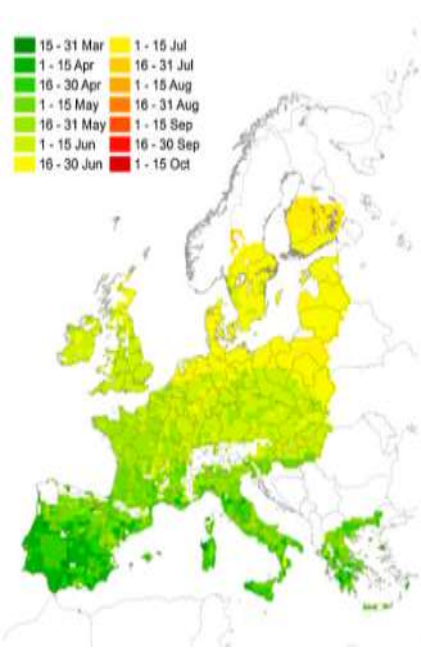


Maritime,
Late semi-dwarf
Long cycle

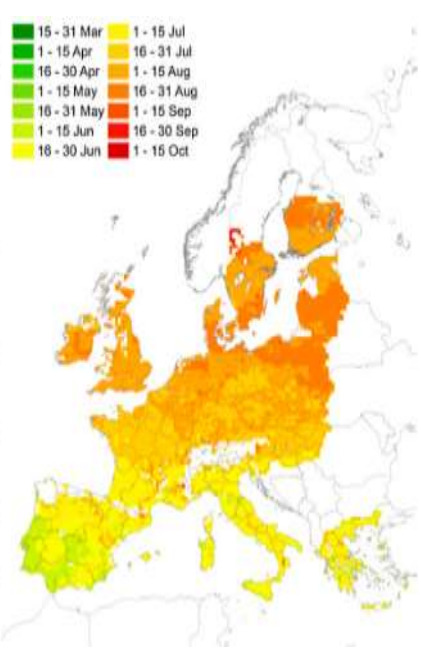
Late Tall
Winterhardy

Medium cycle
Some winter
hardiness

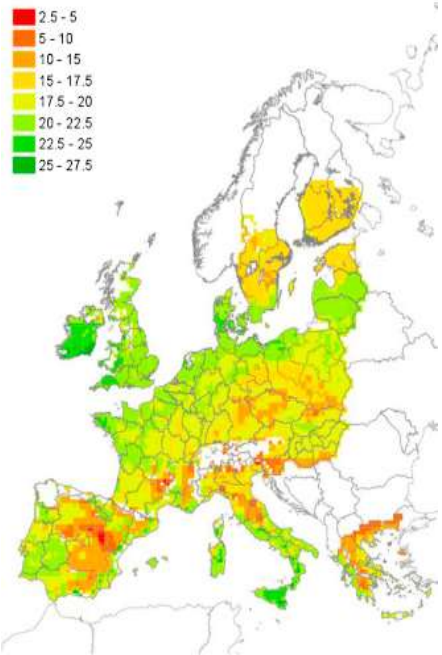
Envirotyping



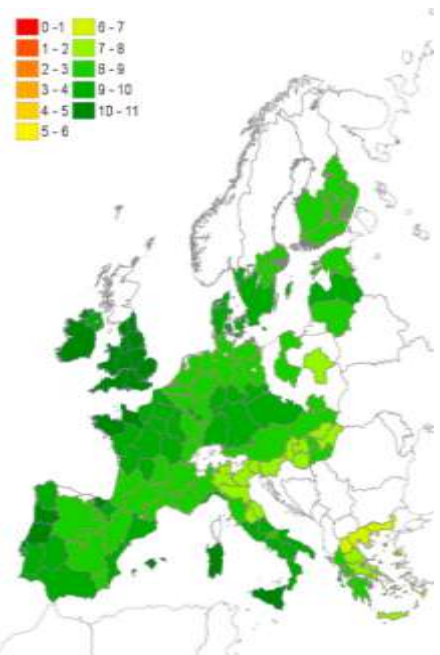
Flowering Date



Ripening Date

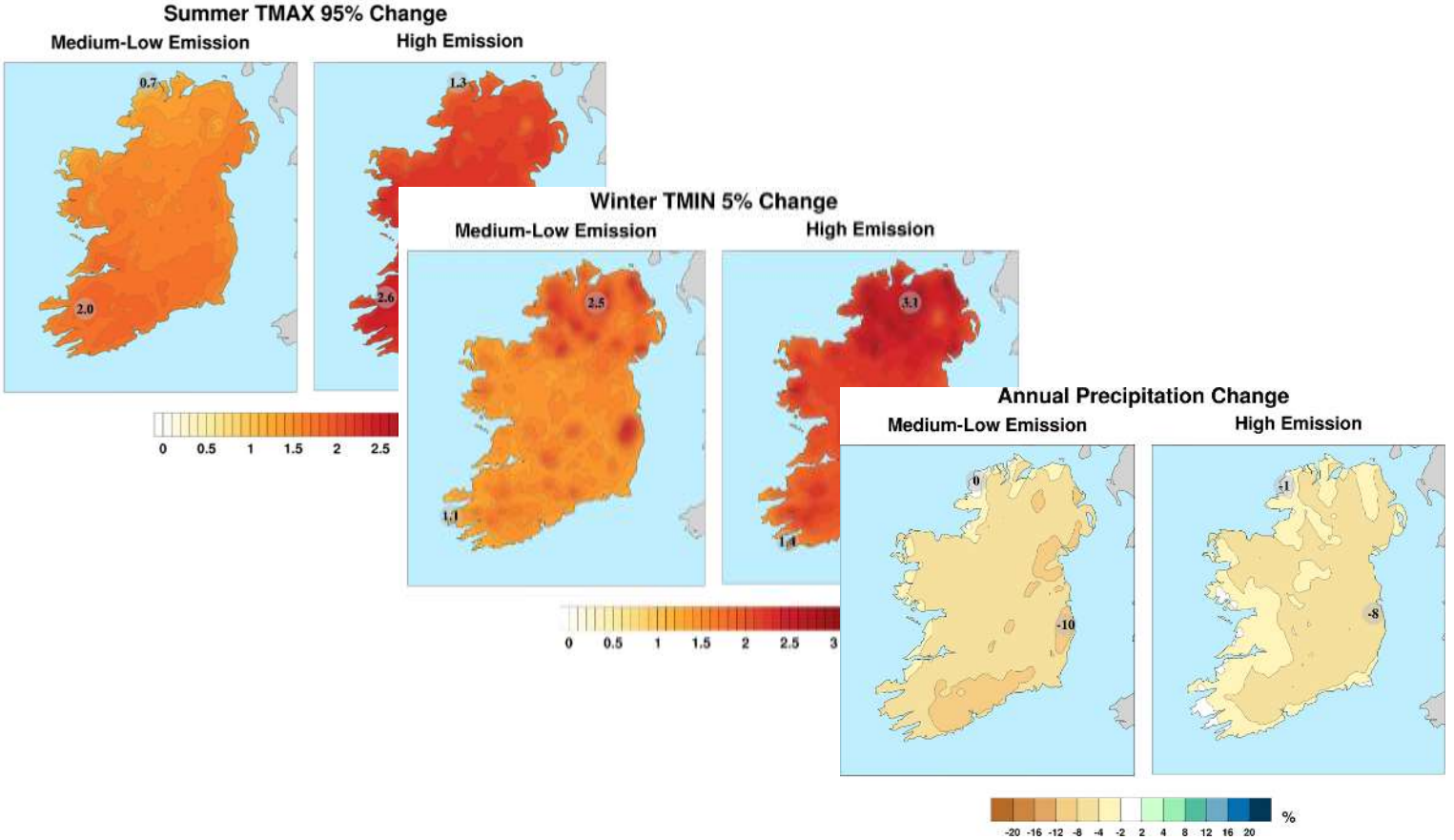


Potential Yield



Actual Yield

Climate change Predictions



Developments in the Breeding Process

Traditional Breeding Approaches

Field Assessment

- Disease
- Plant type
- Agronomy

Yield Assessment

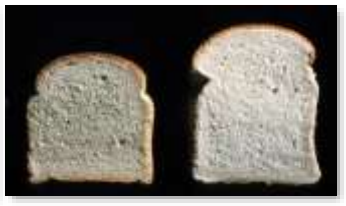
- Automated drilling
- Precision spraying
- On combine weighing

Post-Harvest Assessment

- Grain quality
- Predictive testing
- End product quality





Main Breeding Methods

Pedigree

- Traditional method
- One generation per year, 10 years to market
- Large programme, maintains diversity but slow

Single Seed Descent (SSD)

- 2 or 3 generations in a year
- Requires growth room or glasshouse
- Saves 1 to 2 years

Double Haploids (DH)

- Fixes the new variety in one step
- Requires tissue culture expertise
- Fastest route, saves 2 to 3 years

Modern Breeding Technology

Phenotyping

- Diseases and physiology
- Whole crop or single plants
- Automated systems
- Small plot estimates of yield

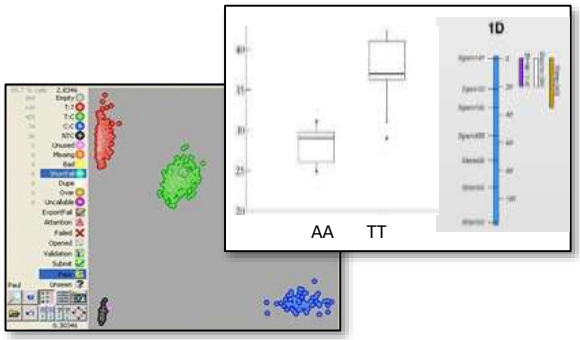
Genotyping

- Simple single genes of large effect

> Marker Assisted Breeding

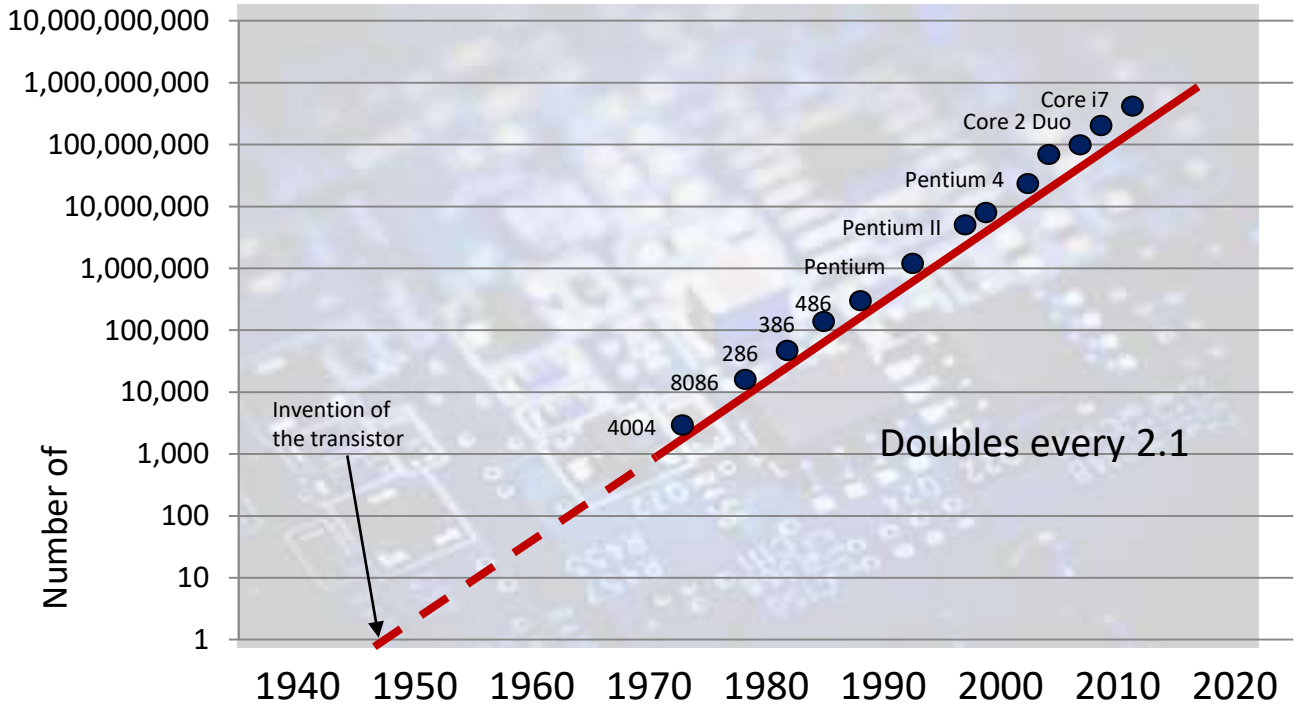
- Complex multi-genes of small effects

> Genome wide analysis

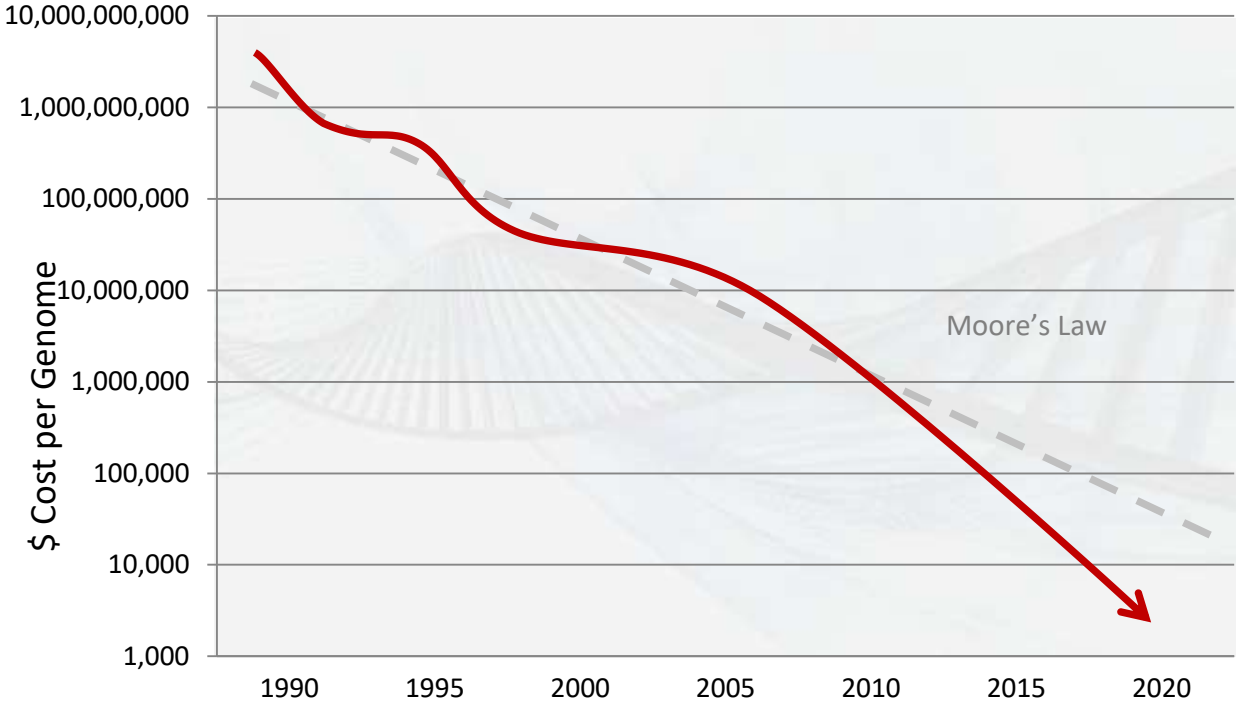


Moore's Law

"The number of transistors on a chip will double approximately every two years."



DNA sequencing costs



Genotyping - Single genes of large effect

Increasing catalogue of commercially important genes

- Disease resistance
- Agronomic traits
- Elements of grain quality
- Yield (grain size)

Marker Assisted breeding

- Profiling parent varieties
- Selecting crosses
- Intense early stage selection
- Stacking novel gene combinations

Key Trait *Septoria tritici* resistance

Septoria tritici

Concerns

- Remains the major yield robbing disease
- Continued loss of fungicide efficacy
  - Both curative and protectant
- Loss of valuable chemistry
- Increasing variability in weather patterns

Septoria tritici

Progress

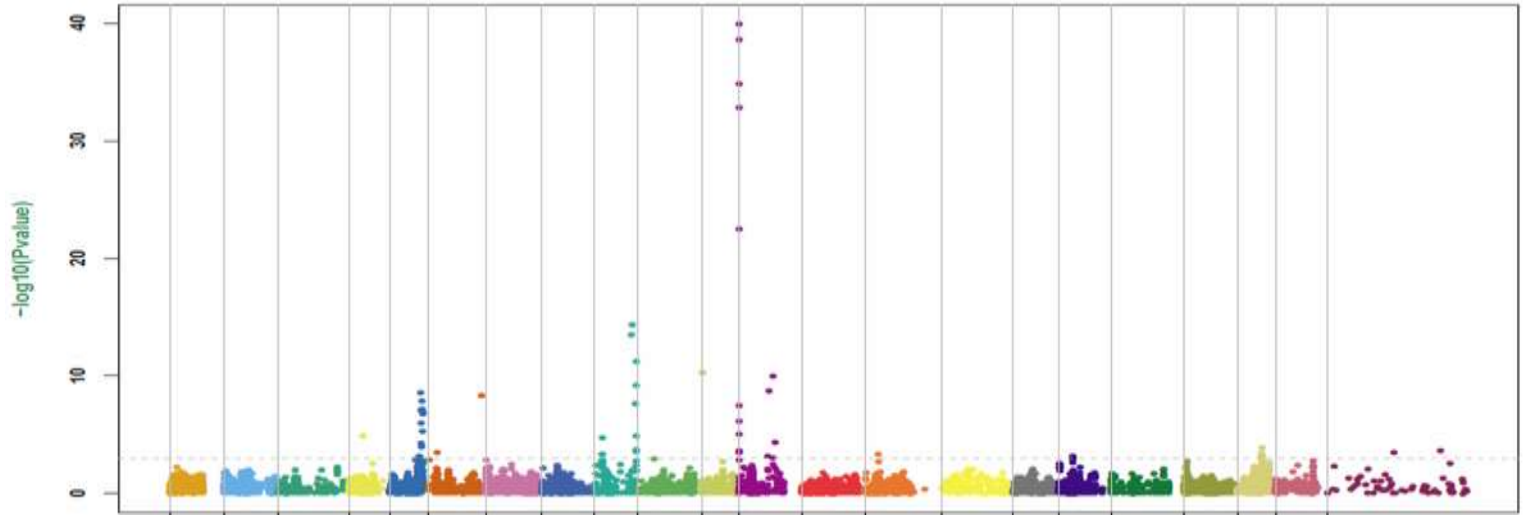
- Multiple sources of resistance identified
- Both in commercial varieties and pre-commercial breeding lines

- High density DNA mapping enables a pipeline of DNA marker development
- Intense screening in multiple high Stb locations
- Priority to stack multiple sources together
- Objective to increase resistance and limit the risk of breakdown

Resistance discovery

Analysis of 1,000's breeding lines

- High Septoria pressure
- A number of key parents with unknown resistance
- Validation for both additivity of resistance & any negatively linked effects



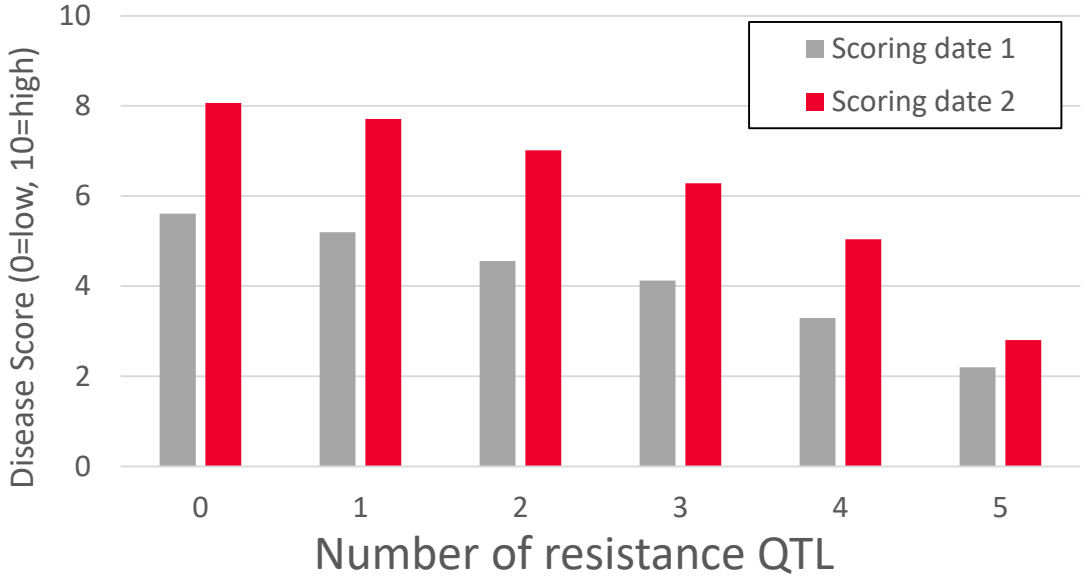
Septoria tritici

Main QTL Effects

	Benefit	Septoria	Yield	SpWt	Height
QTL 1	(+1.0)	***	ns	ns	ns
QTL 2	(+0.5)	***	ns	ns	ns
QTL 3	+0.5	***	*	ns	ns
QTL 4	+0.5	***	ns	ns	ns
QTL 5	+0.8	**	ns	ns	ns
QTL 6	+0.9	***	*	ns	ns
QTL 7	+0.5	***	ns	*	ns
QTL 8	+0.5	***	ns	ns	ns
QTL 9	+0.5	***	**	*	ns

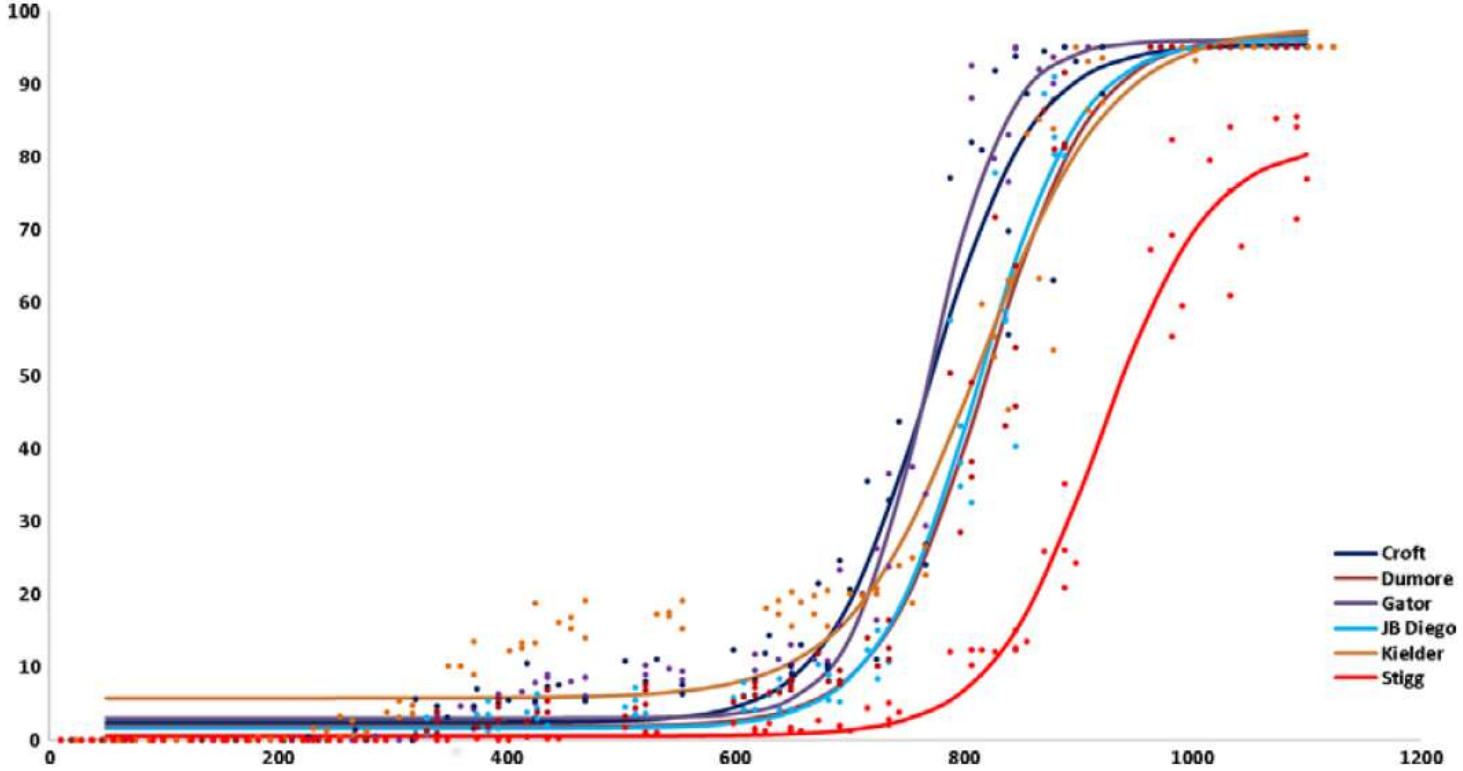
Opportunities

Stacking resistance genes



Mechanisms of resistance

Increased latent period

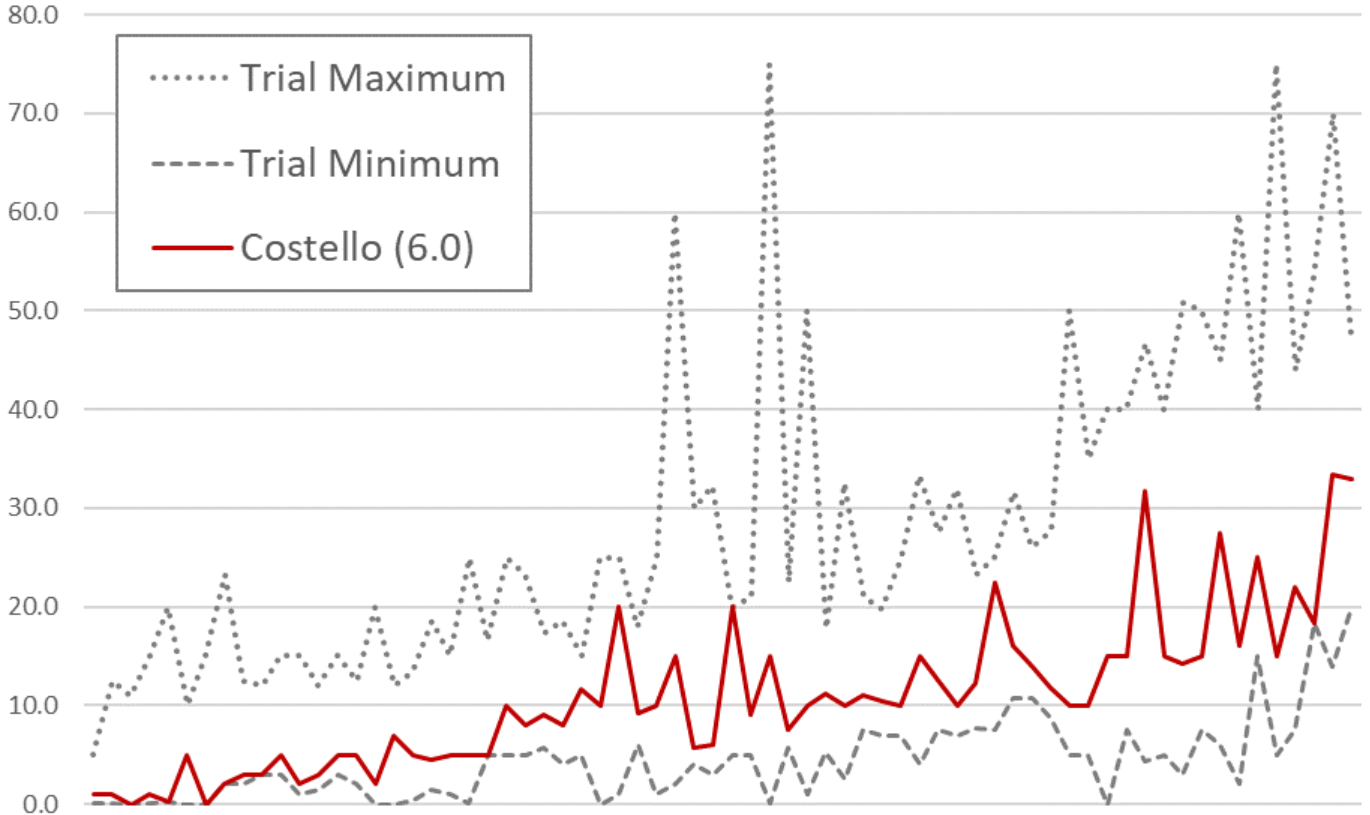


The “Cougar” Project

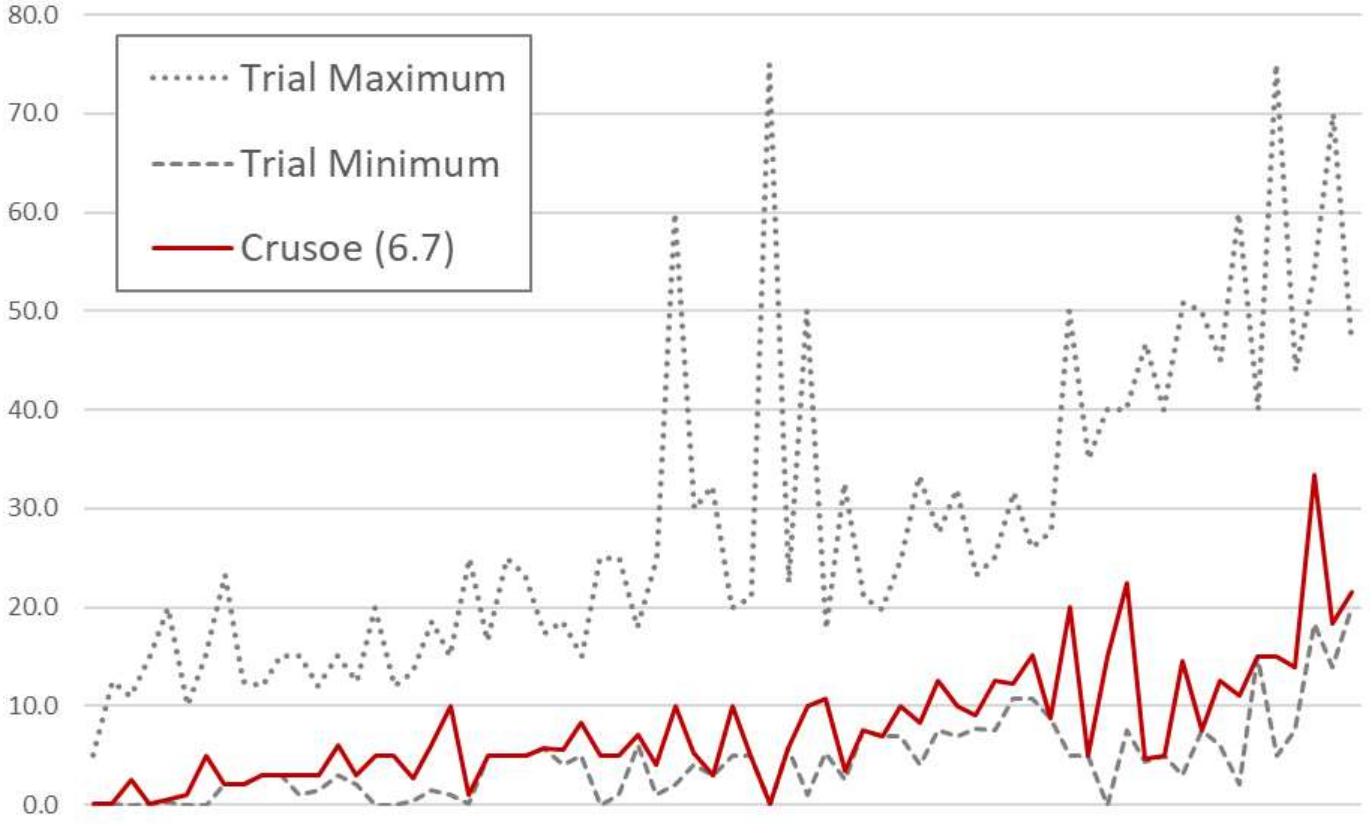
Investigating the frequency & virulence of the Cougar breaking strain(s)

- Collaborative project involving RAGT, Syngenta, DSV and LG
- Increased levels of disease have been seen on Cougar over 3 years
- Many Cougar derivatives remain highly resistant
- Using a panel of varieties to monitor the Cougar breaking strain
- Sampling of Cougar and other varieties to sequence the pathogen both with and without virulence on Cougar to better understand the new strain

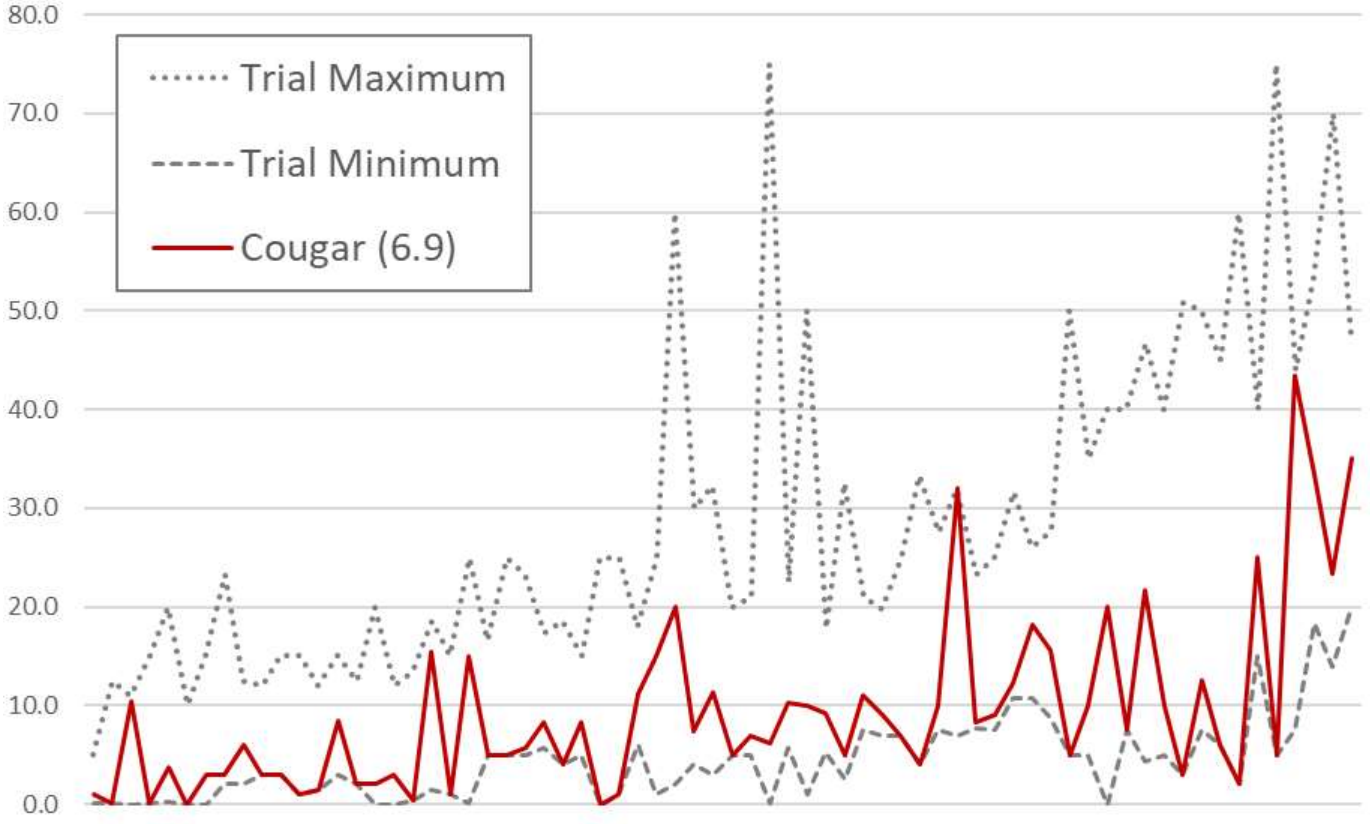
Septoria score by site



Septoria score by site



Septoria score by site

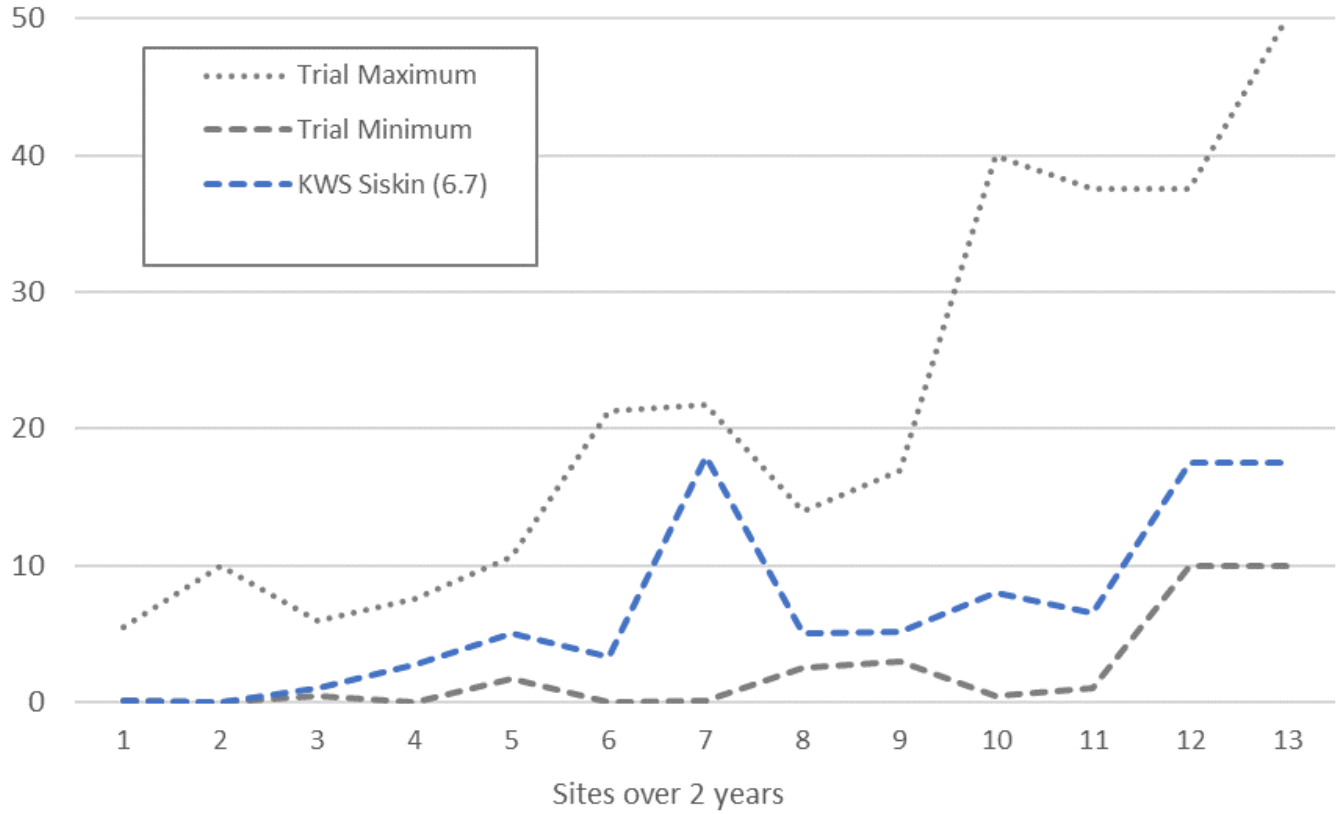


Variety Development

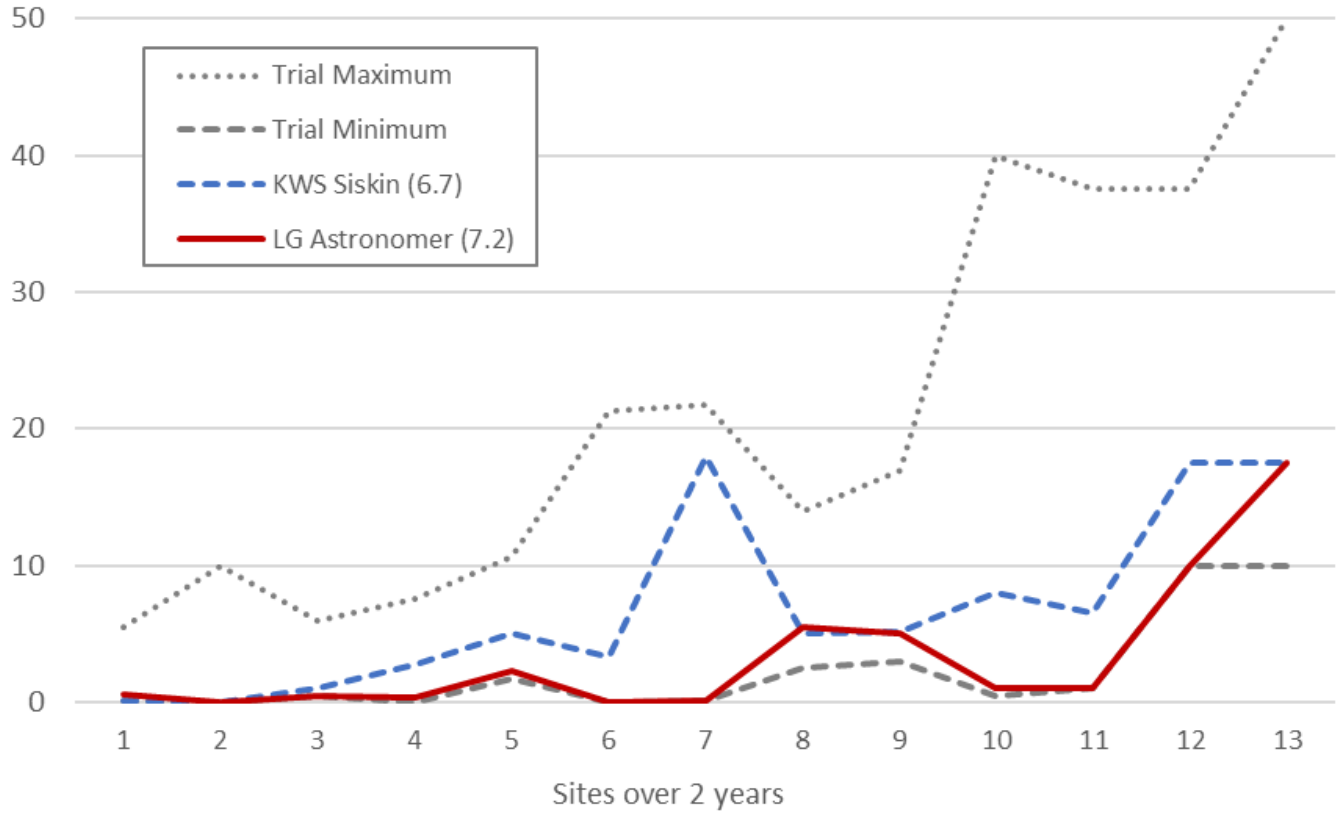
LG ASTRONOMER (LGWU143)

- In official trials across NW Europe (UK, Ireland, Benelux)
- Soft feed variety
- Consistently high treated yield
- Very good grain quality, high specific weight 78+
- High untreated yield
- Due to excellent resistance to yellow rust (9) and *Septoria tritici* (7.2)
- Resistance to both based on a combination of multiple resistances

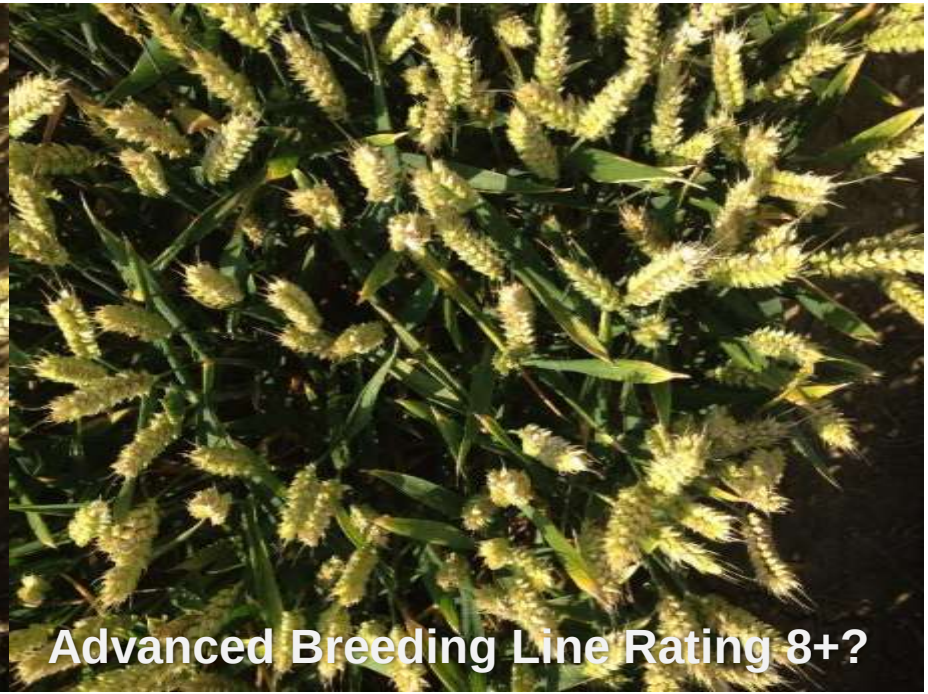
Septoria score by site



Septoria score by site



Where can we get to in the near future



Key Trait Sprouting resistance

Hagberg falling number

The HFN of wheat is affected to a greater or lesser extent by either or both of these two conditions:

Pre-maturity Amylase (PMA)
Intact grain with no visible sprouting

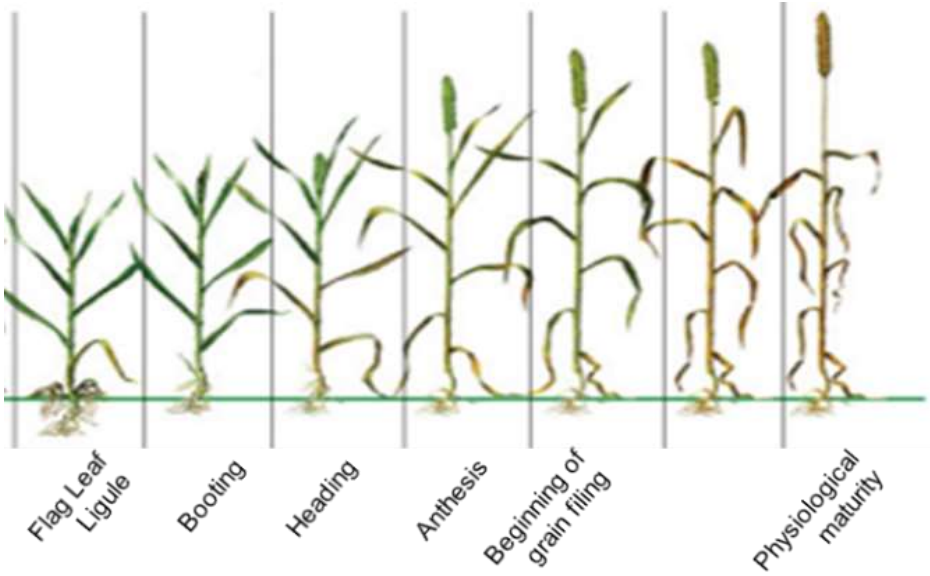
Pre-Harvest Sprouting (PHS)
Visible sprouting of ripe grain

Hagberg Falling Number

The effect of prevailing weather patterns

Pre-maturity Amylase
Occurs when day to day temperatures change by +/-10°C

Pre-Harvest Sprouting
Dormancy broken (by high temperatures)
Warm and wet



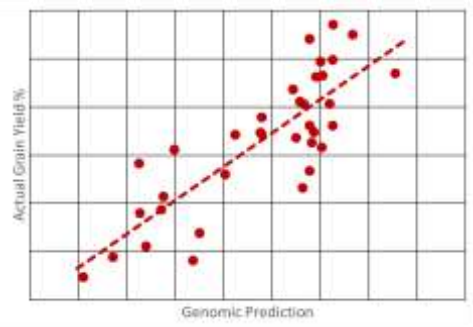
QTL (genes) have now been identified that control both of these effects and can be selected in combination

Cutting Edge Breeding Tools

New Breeding Systems

Genomic Selection

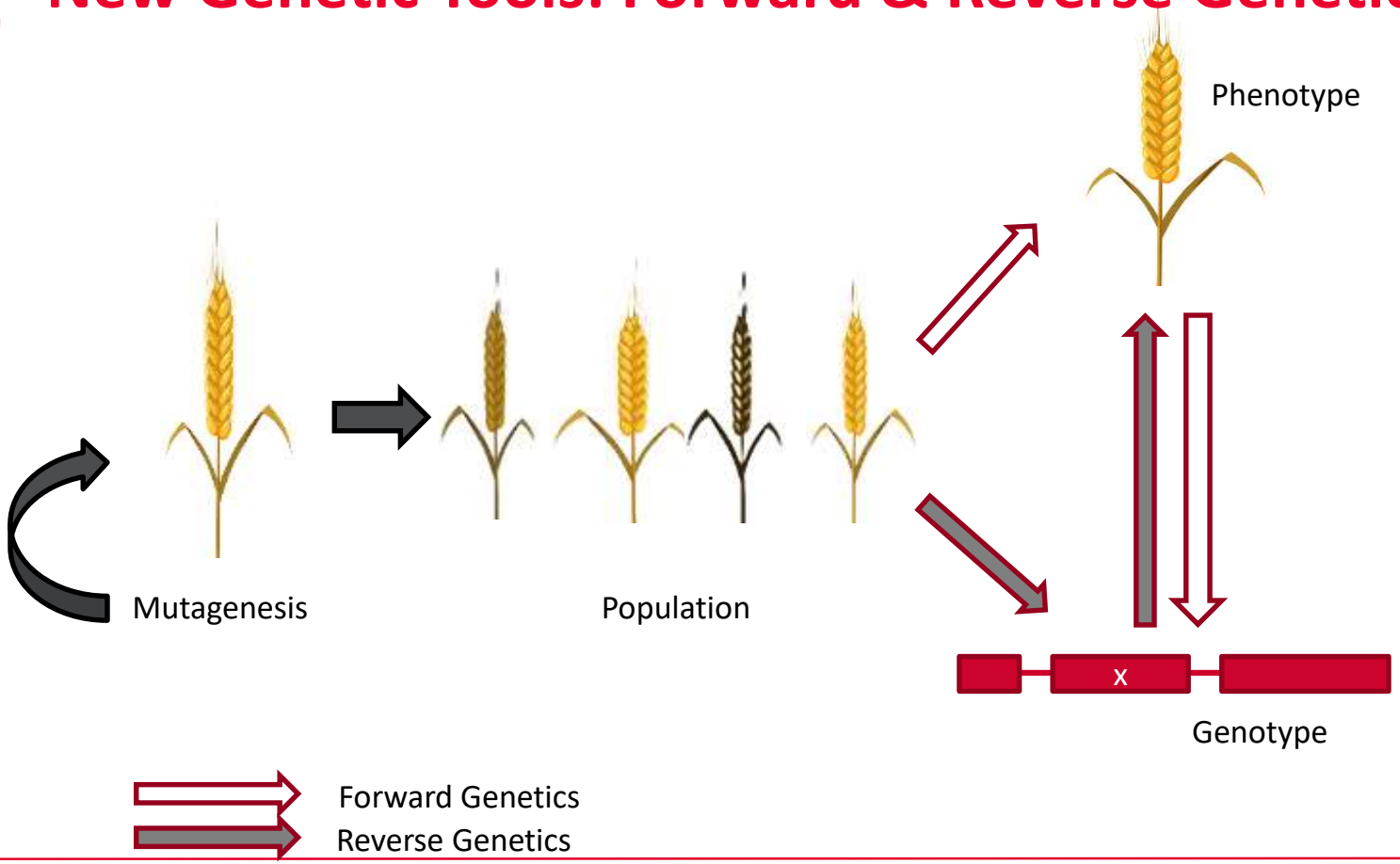
- Used in commercial crop and animal breeding
- Requires high density marker system
- High computational demand
- Potential to increase the rate breeding gain



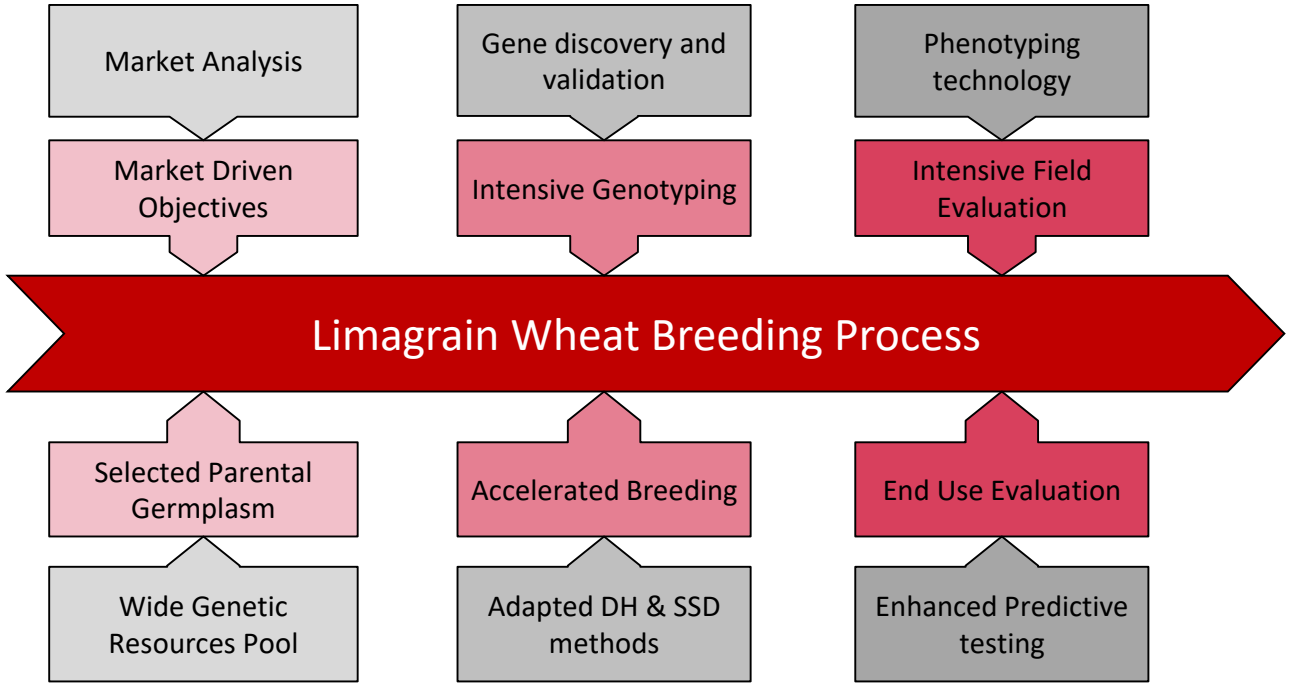
F_1 Hybrids

- Gain from hybrid vigour (heterosis)
- Requires cost effective seed production system
- Chemical emasculation method available
- Genetic solution is more desirable

New Genetic Tools: Forward & Reverse Genetics



Integrated Breeding Platform



The Breeding Challenge

Dependable performance for growers and end-users

- Raising productivity through innovation and maximising genetic potential:
  - **Increasing varietal performance** in a increasingly unpredictable environment
  - **Robust** grain quality
  - **Consistency** of agronomic traits
  - Increasing ***Septoria*** **resistance** and building background **resistance to rust**
  - **Accelerating selection** for insect and virus resistance
- Maintaining a diverse portfolio to suit the evolving needs of both the grower and end market/consumer