BOKU IFA Institute of Biotechnology in Plant Production

ecobreed IMPROVING CROPS

How long does it take to develop high performing and common bunt resistant winter wheat lines using organics-compliant methods?

XXII International Workshop on Bunt and Smut Diseases
June 13 2023, Tulln, Austria

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Wednesday, June 14, 2023

Institute of Biotechnology in Plant Production, IFA Tulln, Austria

The Problem

Common bunt caused by *Tilletia tritici* and *T. laevis*

Refreshing Your Memory...

1. winter wheat trials, sowing in November
2. artificial inoculation with teliospore suspension
3. infection with “IFA Aggressive” inoculum (higher virulence)
4. scoring: cutting open 100 heads per plot
5. incidence in % (0/1 scoring)

Organics-Compliant

common bunt is mainly a problem in **organic agriculture**

- no **seed dressings** with systemic fungicides allowed
- high amount of **farm-saved seeds** sown in Austria
- contamination via **neighbouring fields** possible
- EU organics regulation also binding for **seed production**
- **genome editing** currently regarded as GMO in the EU
- possible future **restrictions** on currently registered fungicides

Organic Agriculture - Acreage Worldwide in 2020

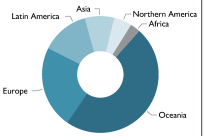
World
74.9M
hectares

Australia
35.69M
hectares

1.6%
of the world´s farmland is organic

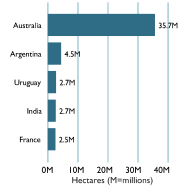
4.1%
growth since 2019

In Oceania there were 35.9 million ha, in Europe 17.1 million ha and in Latin America 9.9 million ha.



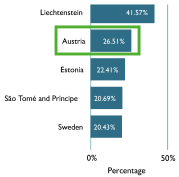
Distribution of organic agricultural land by region 2020.

The ten countries with the largest organic agricultural areas represent 75 % of the world´s organic agricultural land.



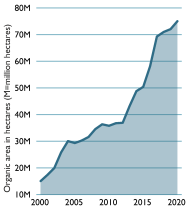
The five countries with the largest areas of organic agricultural land 2020.

18 countries have 10% or more of their agricultural land under organic management.



Top 5 countries with more than 10% of organic agricultural land 2020.

In 2020, nearly 3 million hectares more were reported compared with 2019.



Growth of the organic agricultural land 2000-2020.

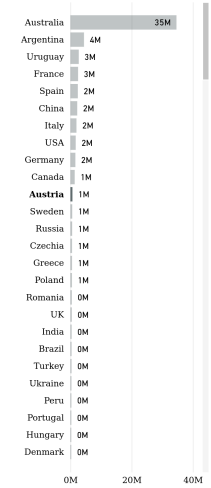
FiBL www.fibl.org

Source: FiBL 2022 www.organic-world.net - statistics.fibl.org

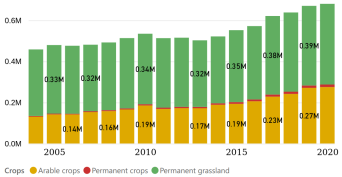
Organic Agriculture - Land Use Development in Austria

Land use: Organic area by country

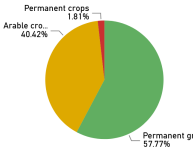
The countries wih the largest organic area in million hectares



Land use development of the organic area in million hectares



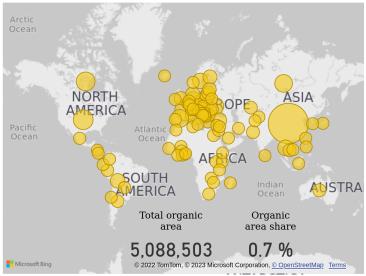
Distribution of the organic area by land use



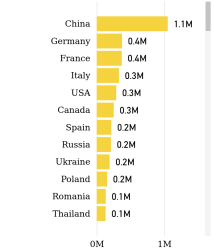
FiBL survey based on national data sources, data from certifiers, and Eurostat: https://statistics.fibl.org

Organic Agriculture - Cereals Production

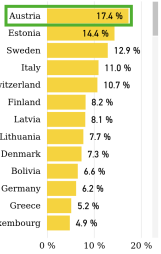
Cereals: Organic area by country



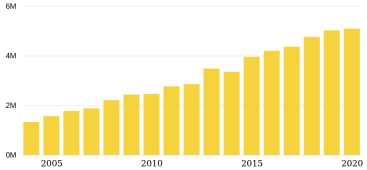
The countries wih the largest organic area in hectares



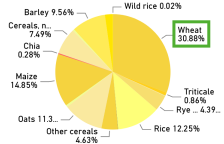
The countries with the highest organic area share in %



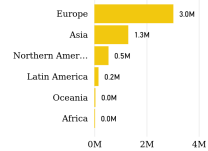
The development of the organic cereal area in hectares



Distribution of the organic area by cereal type



Organic area by continent in hectares



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Project Overview

Aim: Combine marker-assisted foreground and genomics-assisted background selection in populations with introgressed exotic resistance alleles

Key Facts

- experimental "back-cross" population: $BC_3F_{2:5}$
- resistance donors: **Blizzard**, **Bonneville** and **PI119333**
- **marker-assisted** selection via KASP-markers for resistance QTL in F_1 and F_2
- **genomics-assisted** background selection in BC_2F_1 via GEBVs
- validation through **field testing** in generations $F_{2:3}$ and $F_{2:4}$

Common Bunt Resistance QTL

3 resistance donors - QTL mapped by *Muellner et al. (2020, 2021)* - markers available

1A

- major eff. on CB + dwarf bunt (DB)
- 498.5 - 516.6 Mbp
- 205 Blizzard/Bonneville-RILs

1B:

- major effect on CB, no effect on DB
- 8 - 22 Mbp
- 205 Blizzard/Bonneville-RILs

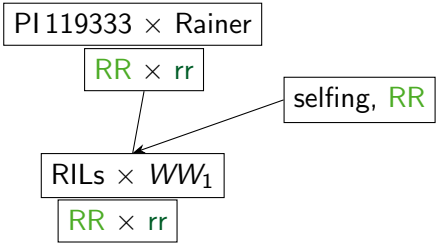
7A

- medium eff. on CB, small eff. on DB
- 711 - 737 Mbp
- 120 Blizzard-RILs

Bt12 - 7D:

- major effect on CB + DB
- 6.5 - 10.8 Mbp
- 80 PI 119333-RILs

Population Development: Example *Bt12*-Population



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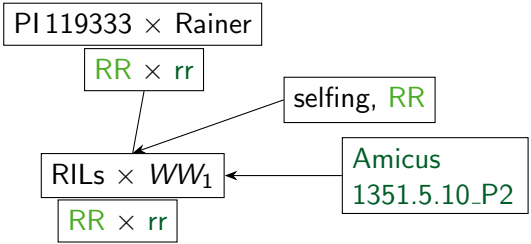

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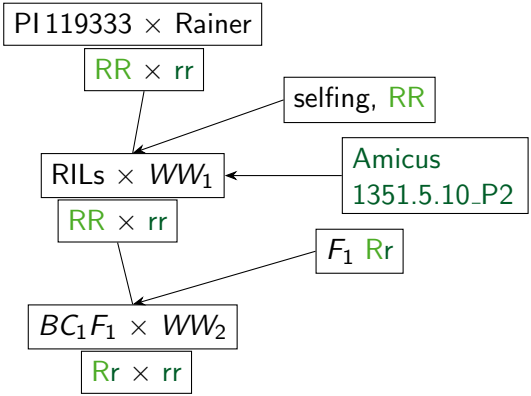

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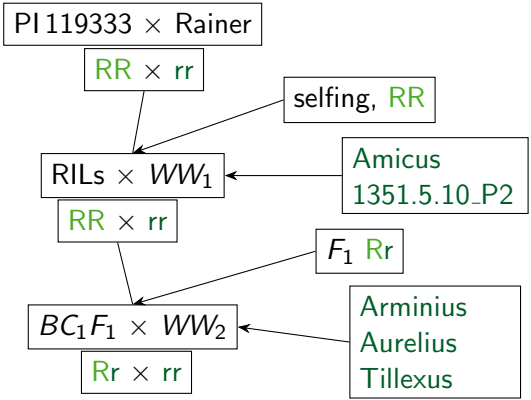

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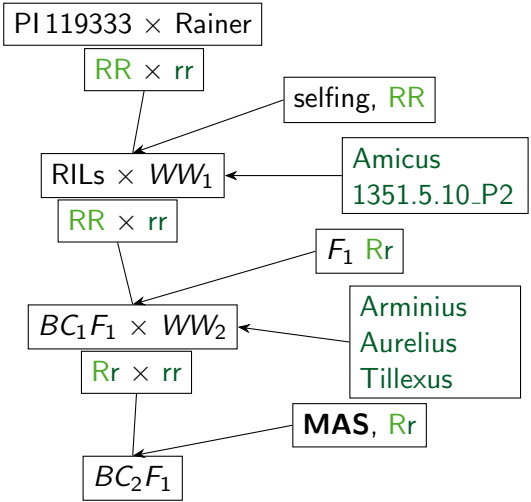

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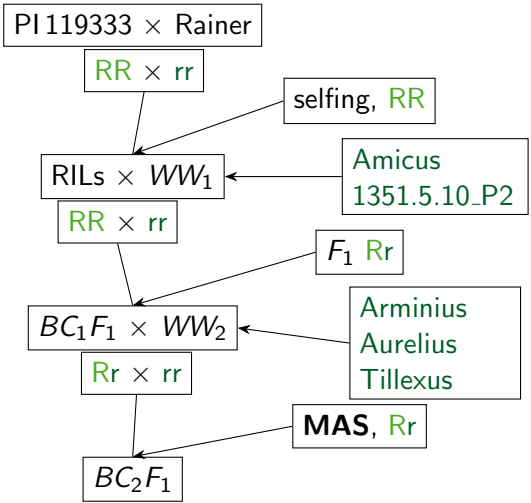

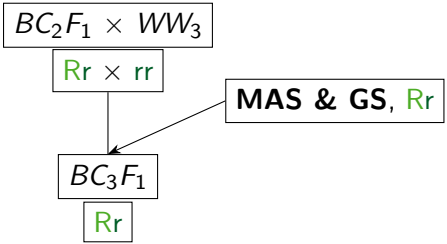

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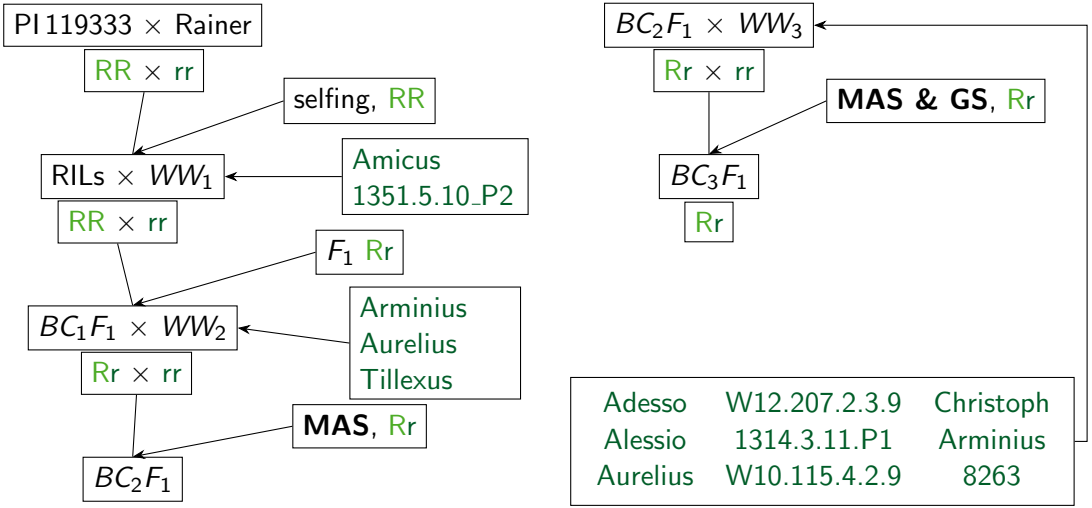

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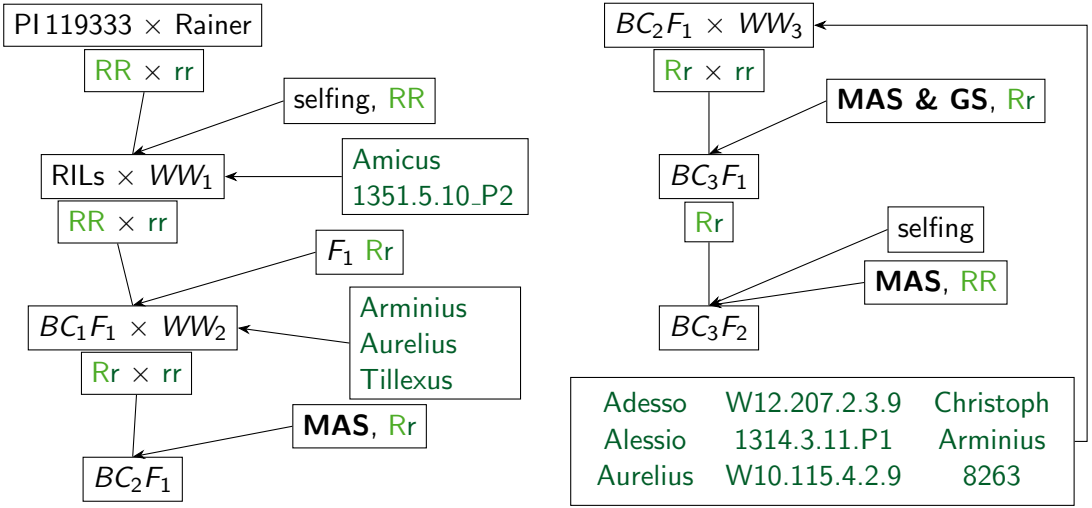
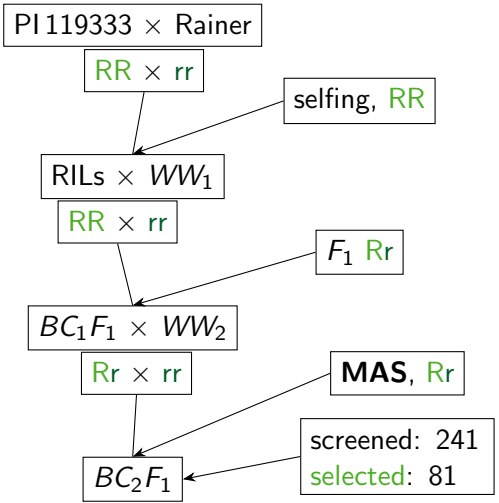
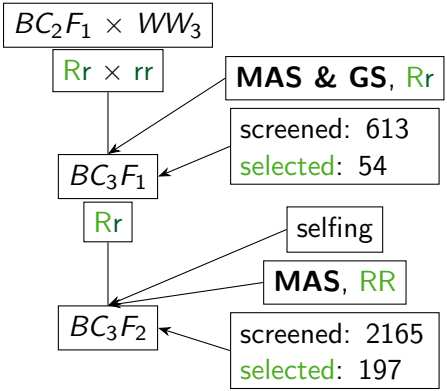
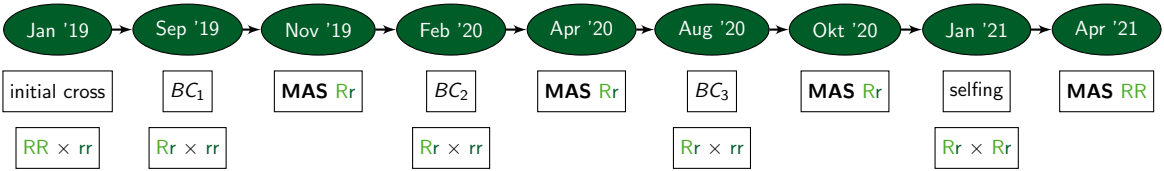


Population Development - Selection Efficiency





Population Development - Theoretical Timeline



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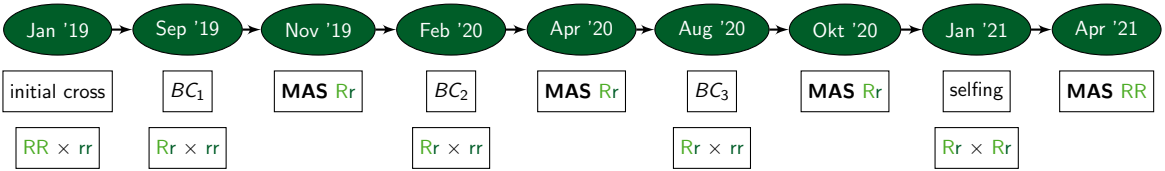

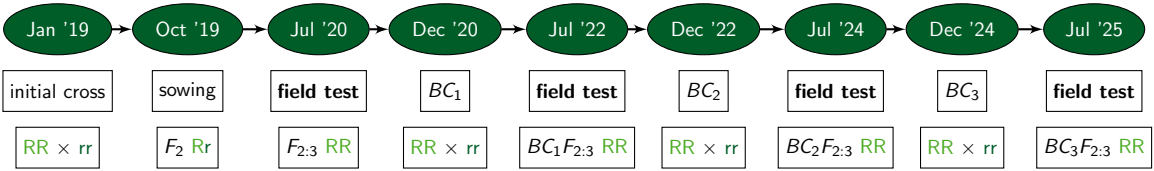

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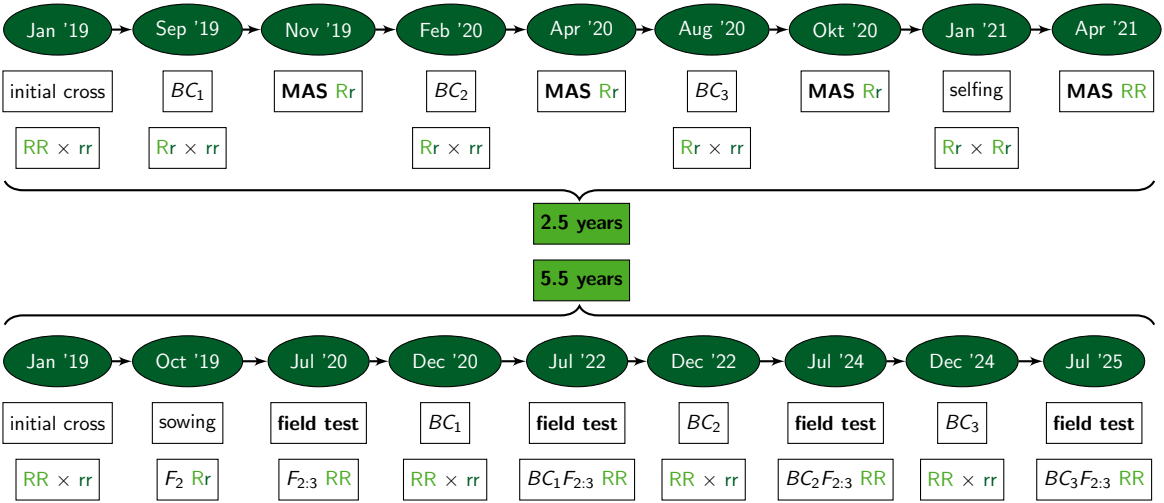
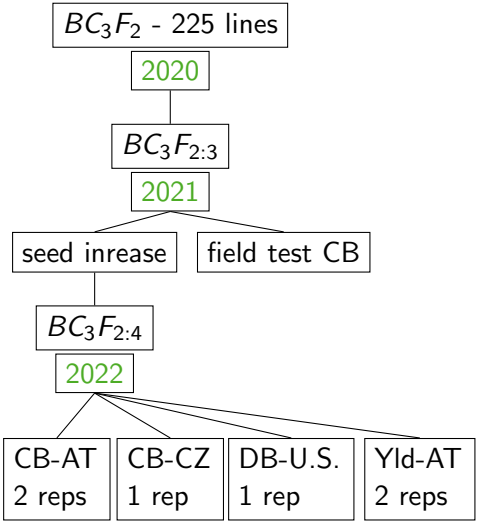


Population Development - Resource Efficiency



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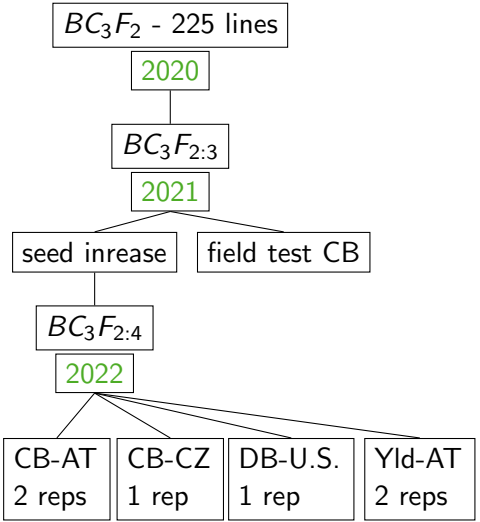
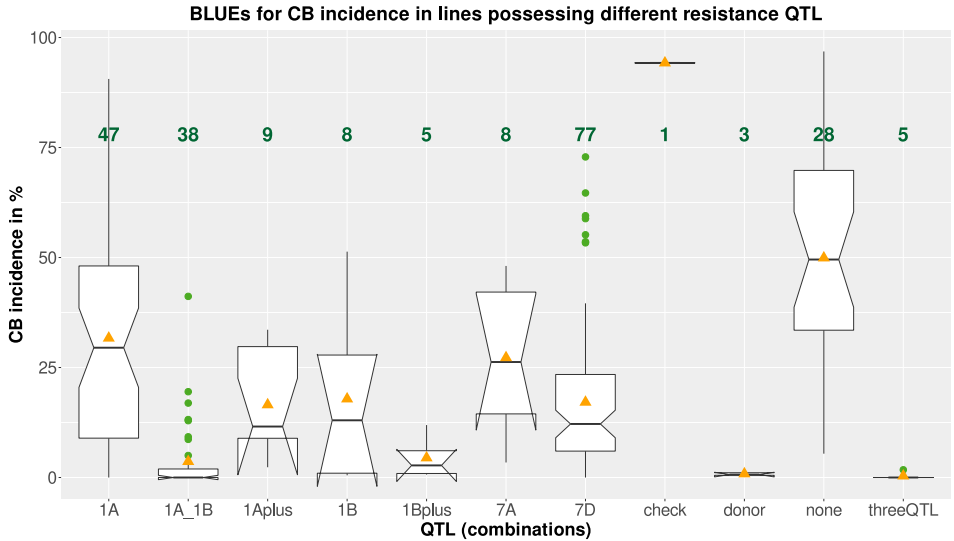


Key Points

1. 3 steps of MAS (BC_2F_1, BC_3F_1, BC_3F_2)
2. 1 step of genomics-assisted selection
3. resource efficiency for field testing:
   - 2165 BC_3F_2 plants **screened** (MAS)
   - 225 **tested** in field trials
   - 106 lines $<10\,\%$ CB incidence
4. 5 different genotypes/pedigree
5. all lines genotyped with 7K SNP-array

Goal 1: Is It Bunt Resistant?



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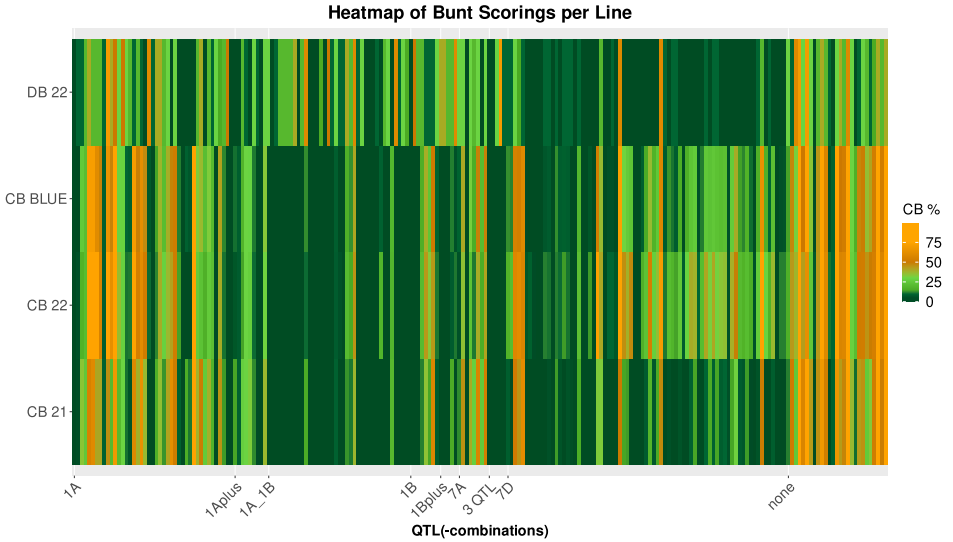
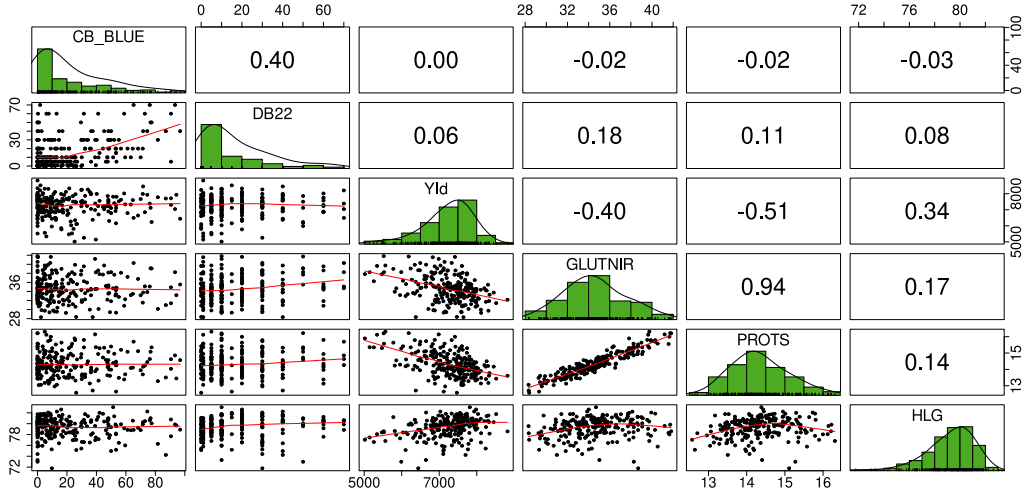


Goal 2: Is It Also High-Performing?



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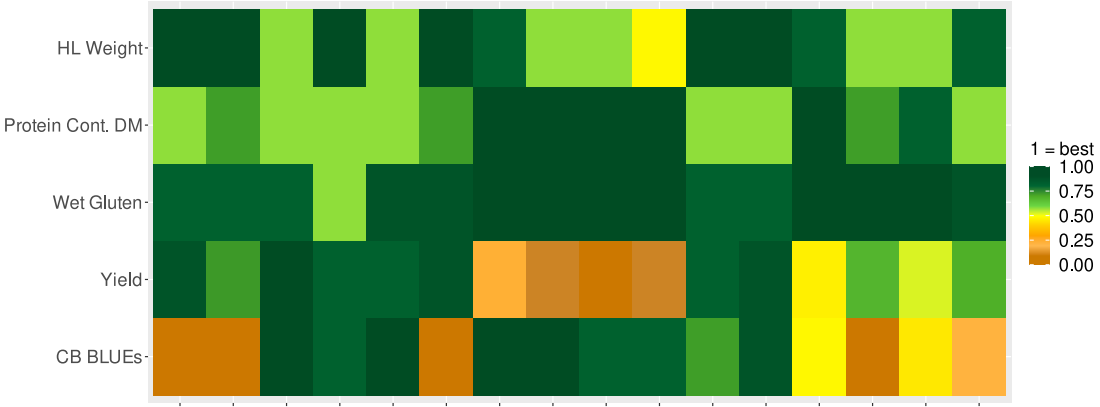

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Conclusions and Outlook

Application of **MAS reduces time** needed for population development by **more than** 50 %

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- selection escapes due to **unsuitable markers** and **recombination events**
- high genetic variation through complex pedigrees - "**background selection**"

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- testing under **organic conditions** missing
- durable bunt resistance needed - **stacking** of resistance loci

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Successful development of breeding material combining **resistance to bunt diseases** with **competitive yield and quality** characteristics

Supervisors, Collaborators and Funding Agencies

- Hermann Bürstmayr and all colleagues at the institute (IFA-BP)
- AgriGenomics DocSchool & Advisory Board
- Margaret Krause (Utah State University, U.S.)
- Veronika Dumalasová (CRI Prague-Ruzyně, CZ)
- Austrian Academy of Sciences (OEAW) - DOC-fellowship (grant nr. 25453)
- ECOBREED[1] - Heinrich Grausgruber

[1] The research carried out within ECOBREED is receiving funding from the European Union Horizon 2020 under the Grant Agreement number 771367, within the Research and Innovation action (RIA).

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Thank you for your attention!

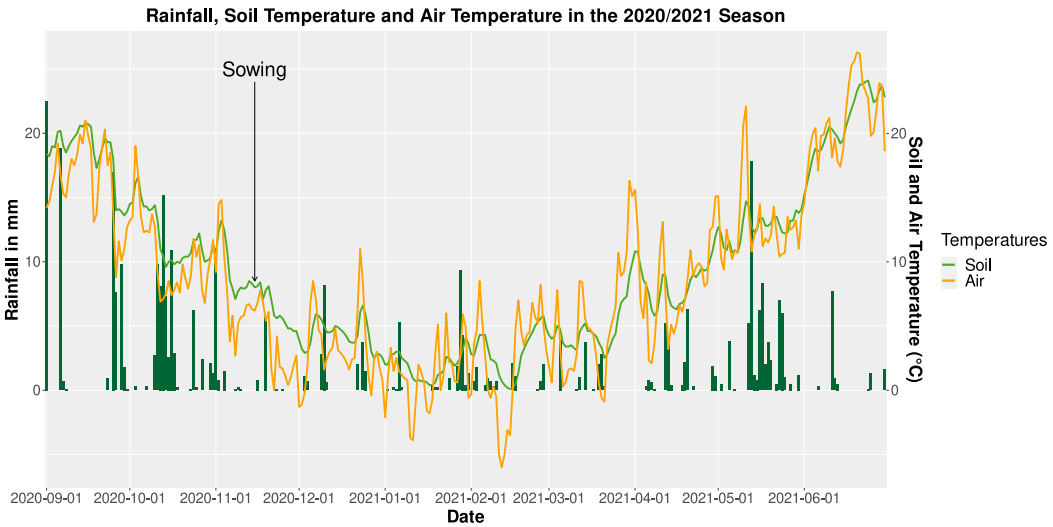
Marker Polymorphisms: Example *Bt12*-Population

resistance donor has Allele 1, all other parental lines in pedigree have Allele 2

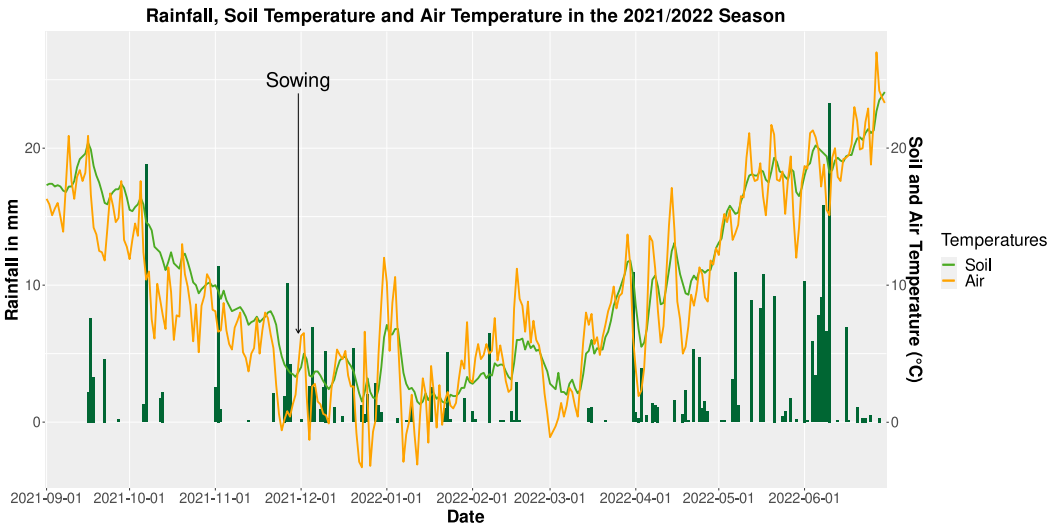
Marker	47	48	49	50	51
Mbp	10.8	10.7	9.3	8.3	8.2
BC_1					
Amicus	0	0	1	1	0
1351.5.10	1	1	1	1	1
BC_2					
Arminius	1	1	1	1	1
Aurelius	1	1	1	1	1
Tillexus	1	1	1	1	1

	47	48	49	50	51
	10.8	10.7	9.3	8.3	8.2
BC_3					
Adesso	0	0	1	0	0
Alessio	1	1	1	1	1
Christoph	1	1	1	1	1
1314.3.11	1	1	1	1	1
W10.115	1	0	0	0	1
W12.207	1	0	0	0	1
SZD8263	1	1	1	1	1

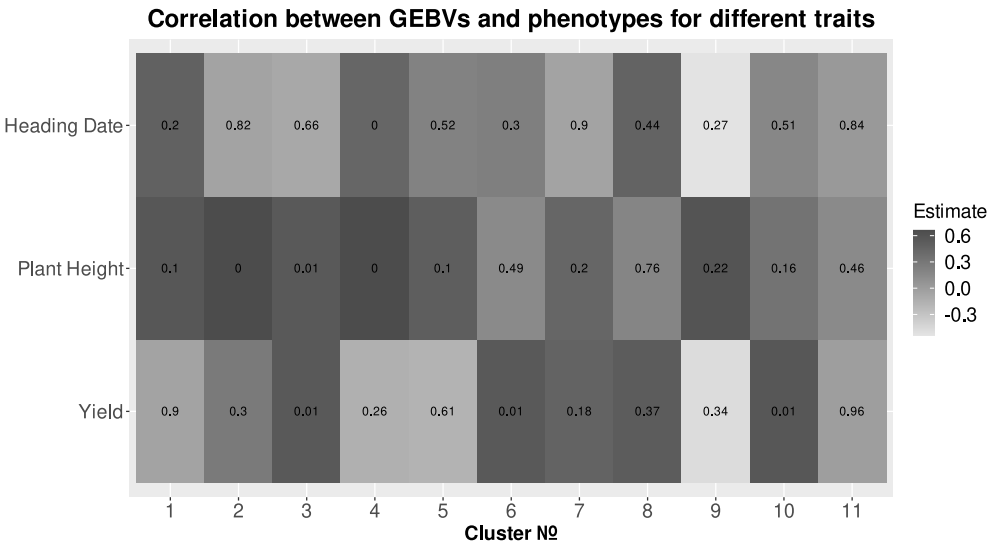
Environmental conditions 2020/21



Environmental conditions 2021/22



Correlations with GEBVs



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