Master's Thesis

Development and Validation of a Model for Genomic Selection for Late Blight in Potato

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Science for [life]

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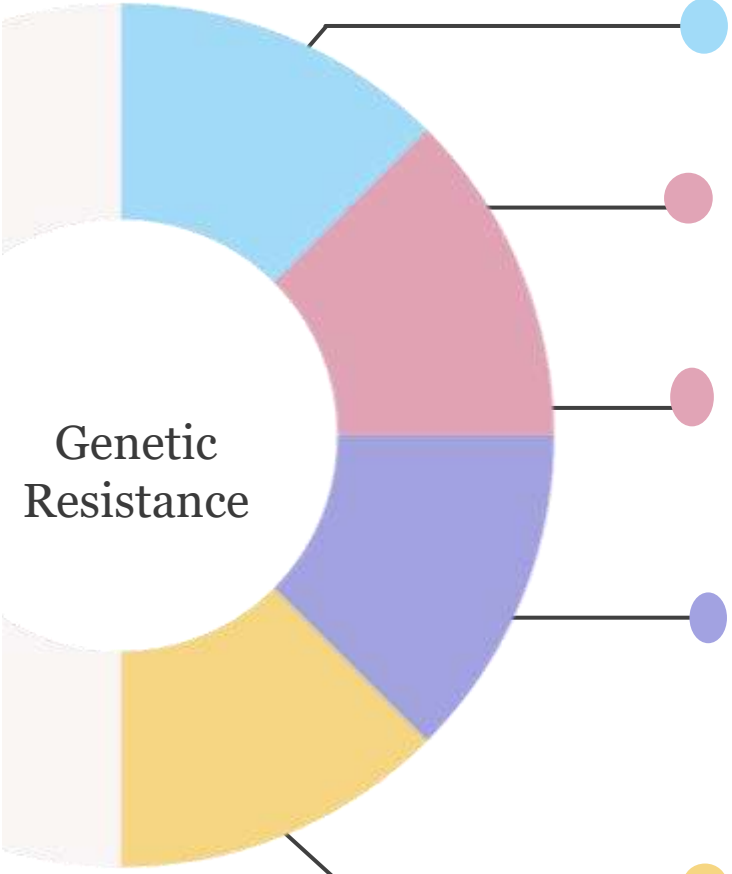
Why Plant Protection Needs Breeding



Durable resistance — Long lasting solution

Stability — Stable resistance across environments

Integration — Integration with IPM

Economical — Economically viable

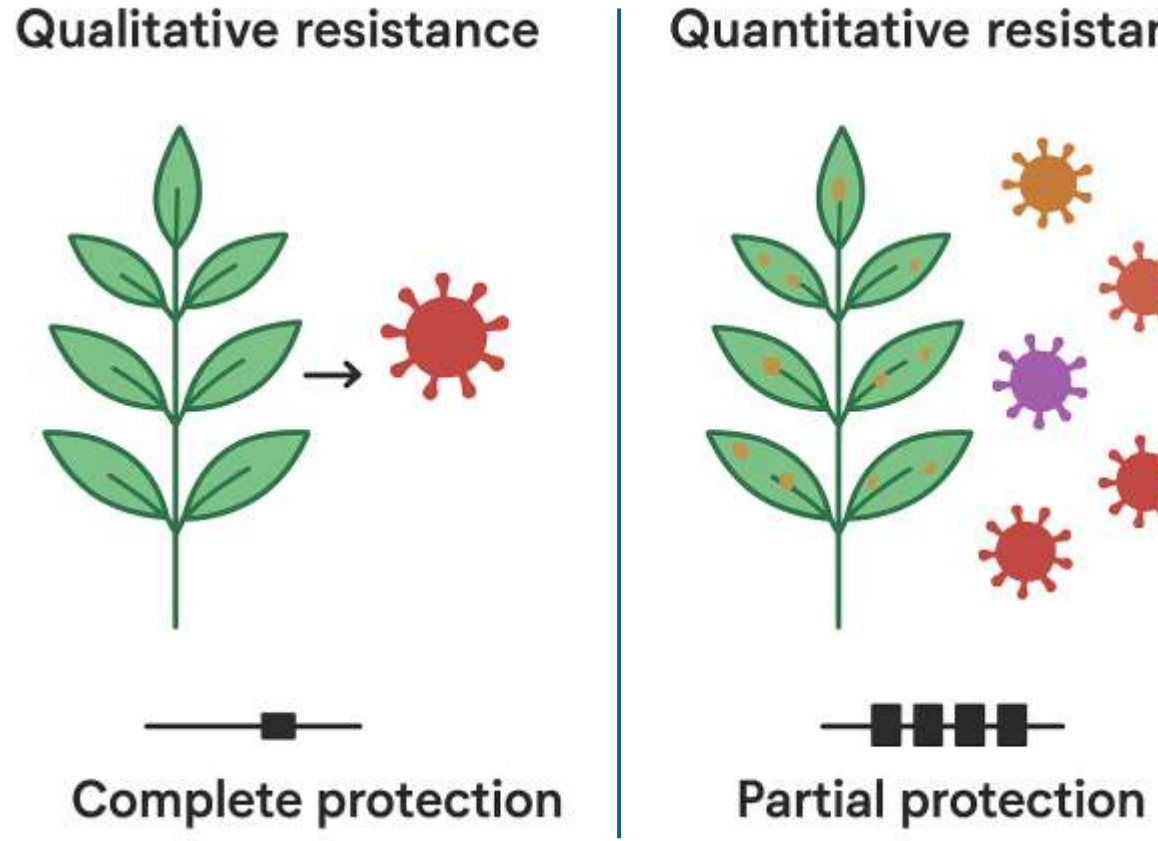
Acceptable — Organic production

Monogenic

Non-durable

Race specific

Introgression



Polygenic (QTLs)

Durable

Race non-specific

MAS/GS

Highly evolving pathogen

Long breeding cycle

Complex Potato Genetics

Poland et al., 2009

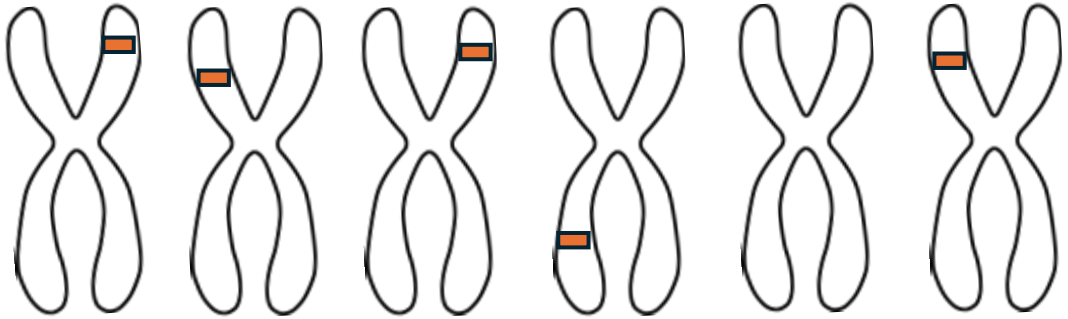
R-gene Resistance

High selective pressure

Non-Durable

Identify & Introgression

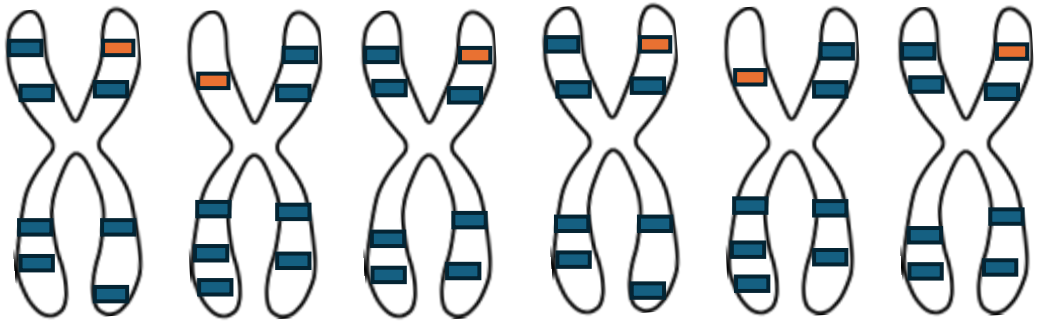
Major QTLs (MAS)



Durable

Map and introgress

Major and Minor QTLs (GS)



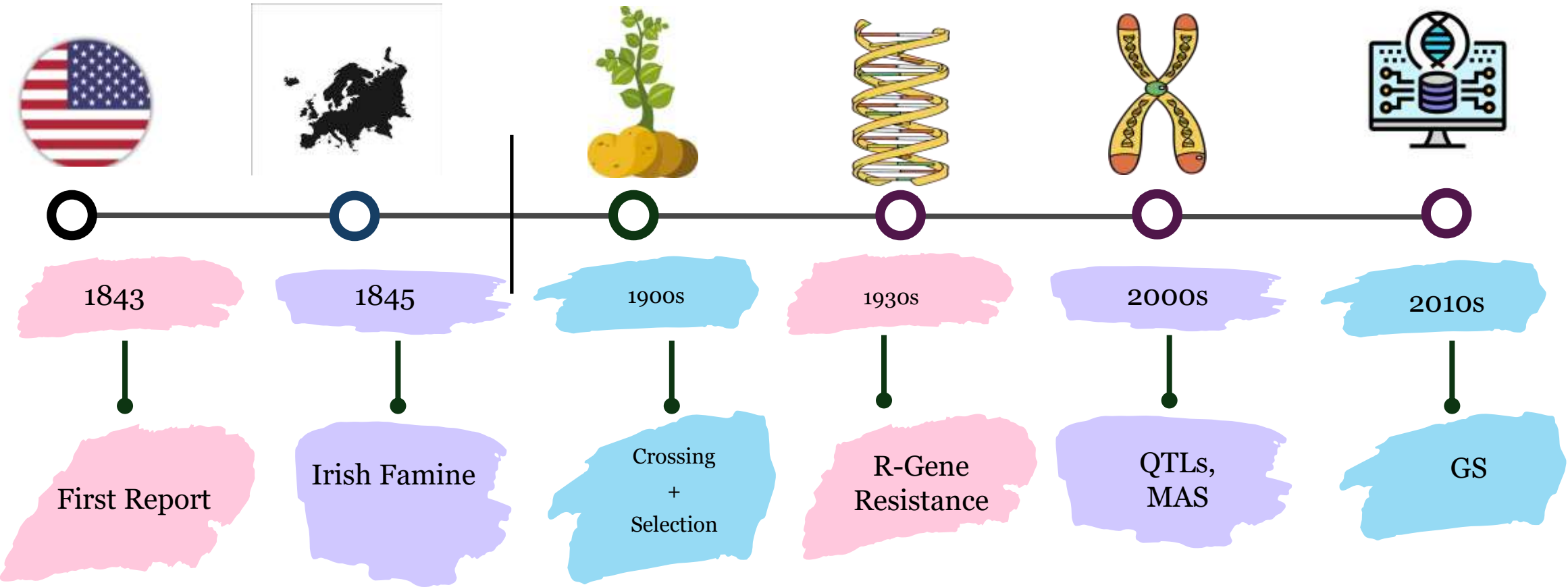
Durable
Less selective pressure

Modelling

Poland et al., 2009

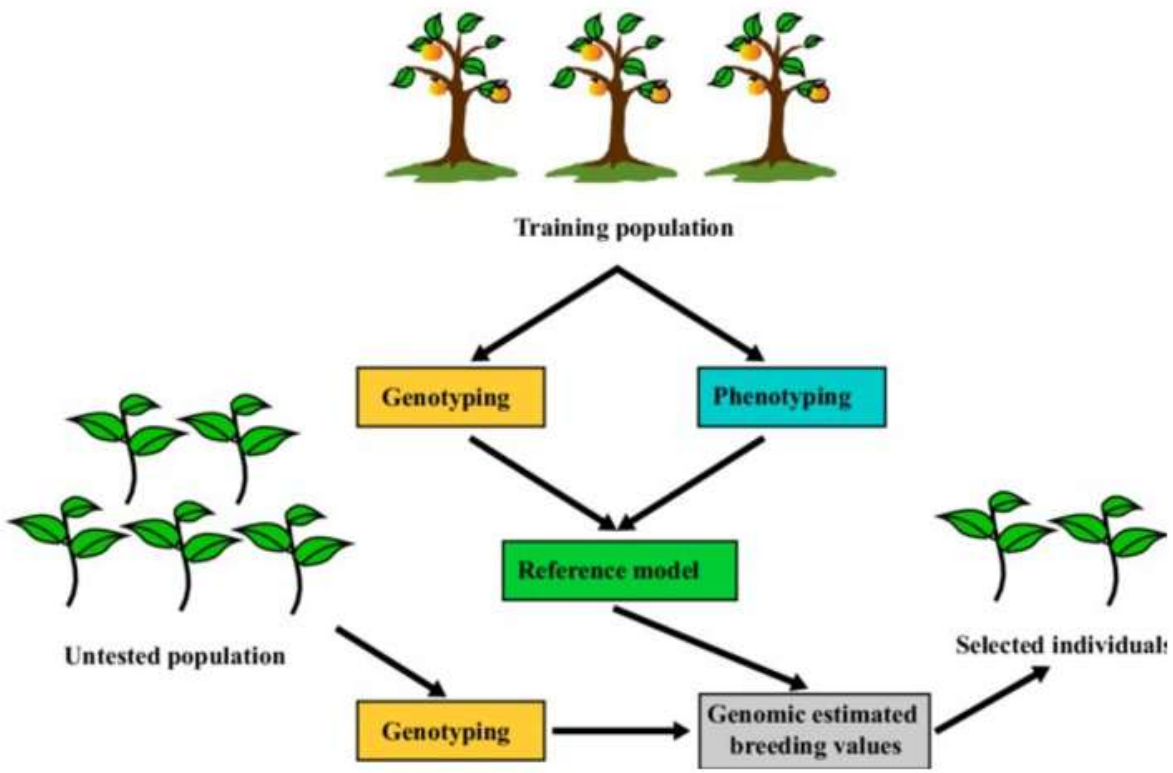
Genetic Resistance

LATE BLIGHT: A Problem over century



Paluchowska et al., 2022; Danen et al., 2010; Poland et al., 2009

Genomic Selection

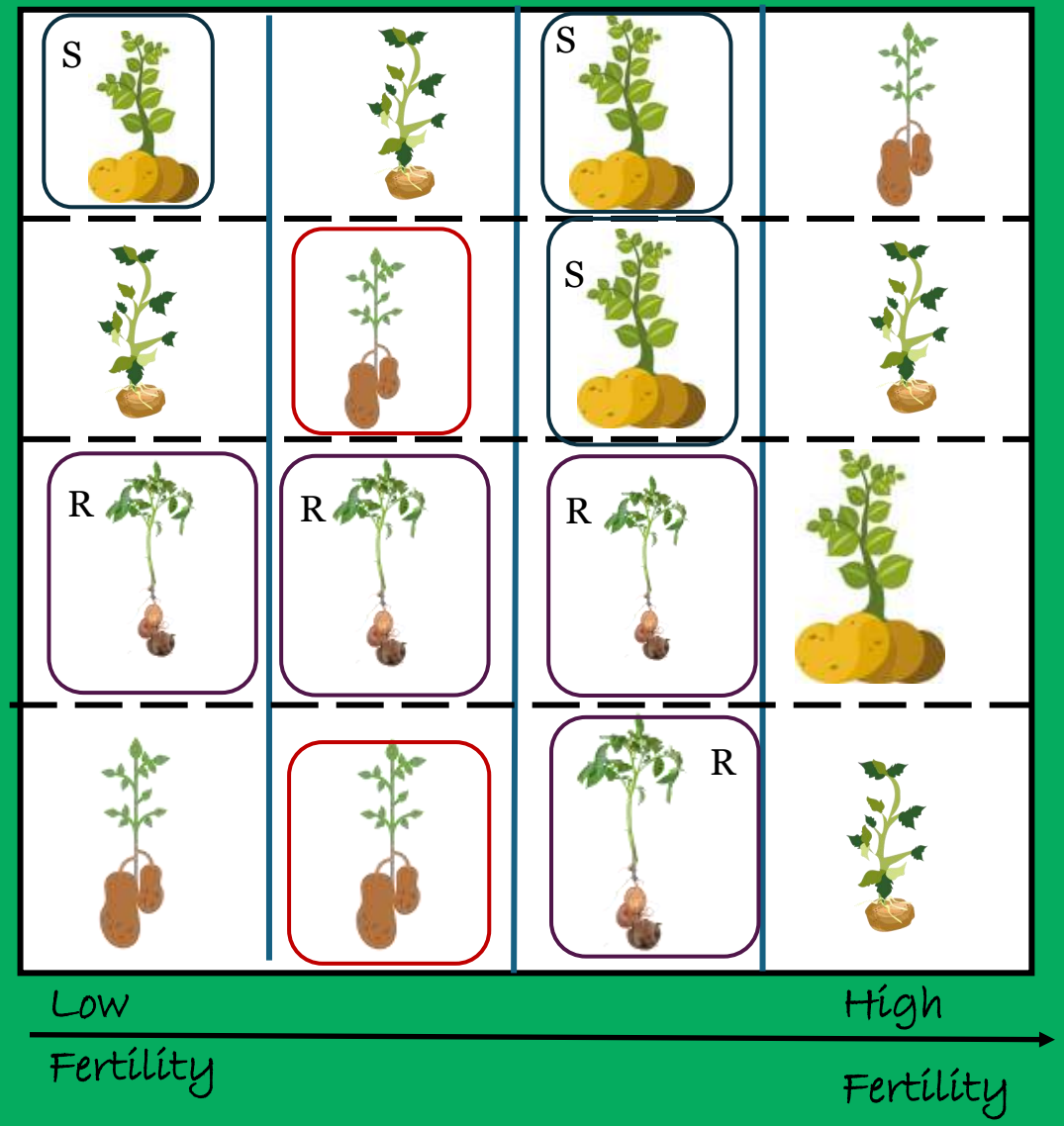


Liu et al., 2022

- ✓ Out of 144 QTLs, 25 % -Resistance Gene Analogues (RGA),50% -Durable Resistance Loci (DRLs) (Danan et al. 2011)

- ✓ Prediction of untested lines
- ✓ Breeding value of tested lines

Sources of Variation



- **Additive Genetic Effects**
- **Non-Additive Genetic Effects**
- Environment
- G X E Interaction
- Spatial Effects
- Neighboring Effects
- Residual Effects

Materials and Methods

Plant Materials

Table 1 Description of potato lines tested over different years.

	2024	2023	2022
No. of plots	4000	2970	3078
Lines tested	1212	975	1717
Lanes (Blocks)	3	2	2
Rows	18	18	18
Columns	84	110	86

Table 2 Description of potato lines, grouped by market segment.

Group	Notation	No. of records	No. of lines
1	Very Early	74	11
2	Early	109	3
3	Table North(North Europe)	1703	346
4	Table South without frying quality	1253	259
5	Red	16	1
6	Salad types	165	28
7	Table north with frying quality	1163	341
8	French fry	1502	415
9	Chips/Crisps	763	194
10	Starch	2985	1465
11	Starch	4	1
12	Starch	334	132
13	Unknown	4	1

Field Design

- Blocks: 2
- Testing Rows: 18
  Spreader Rows: 10
- Columns: 86

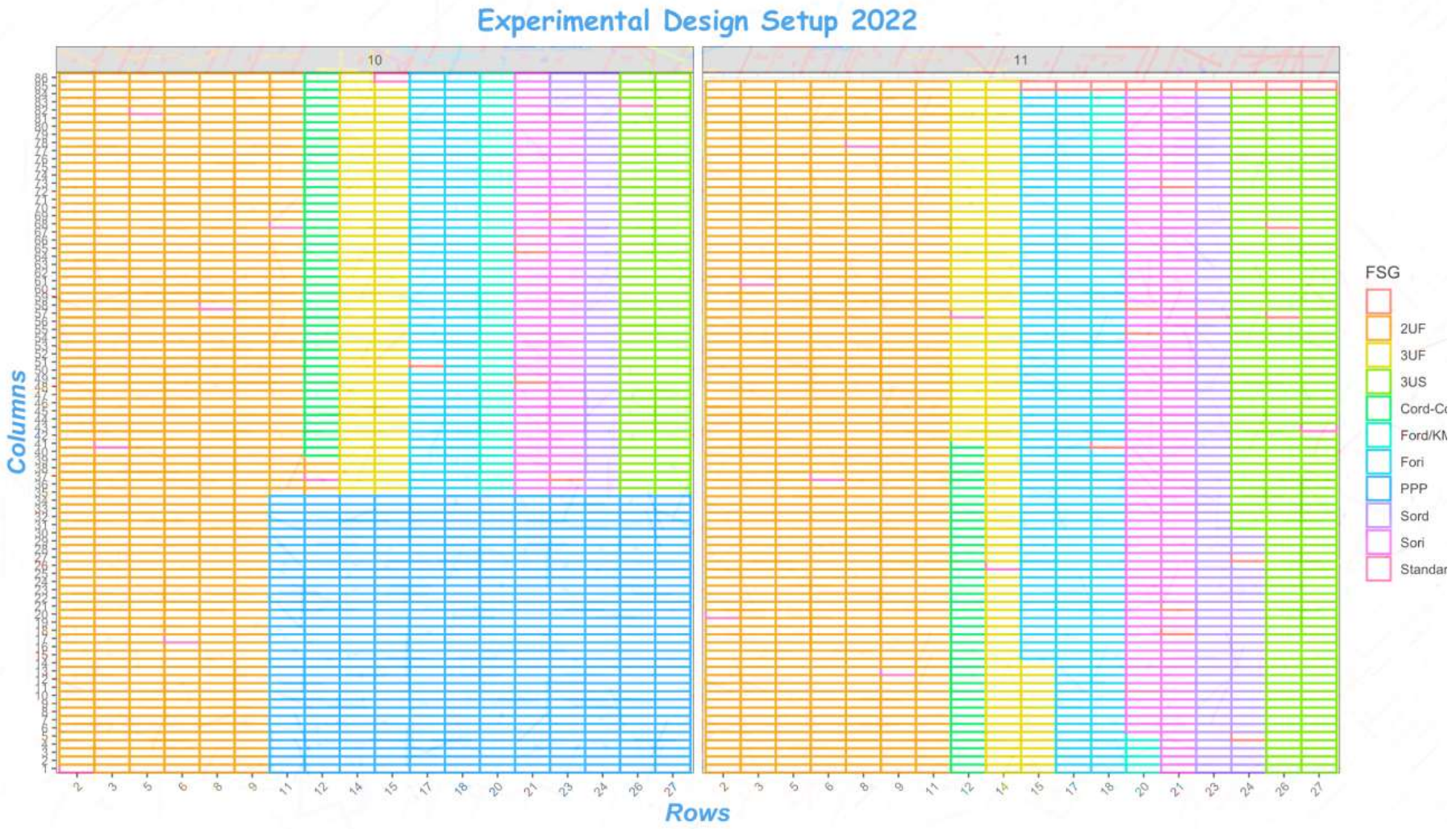
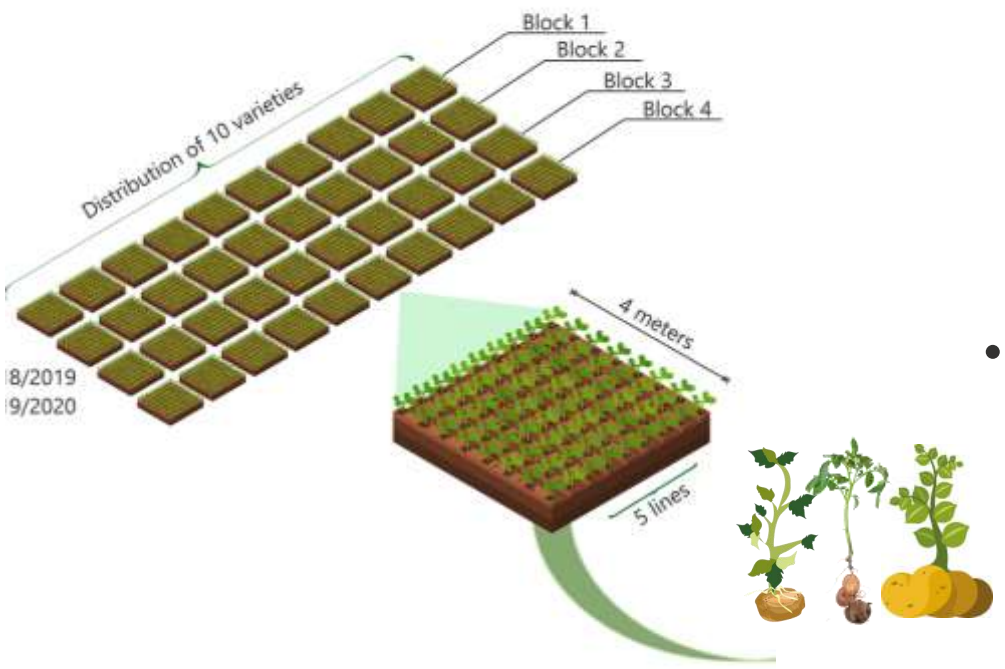
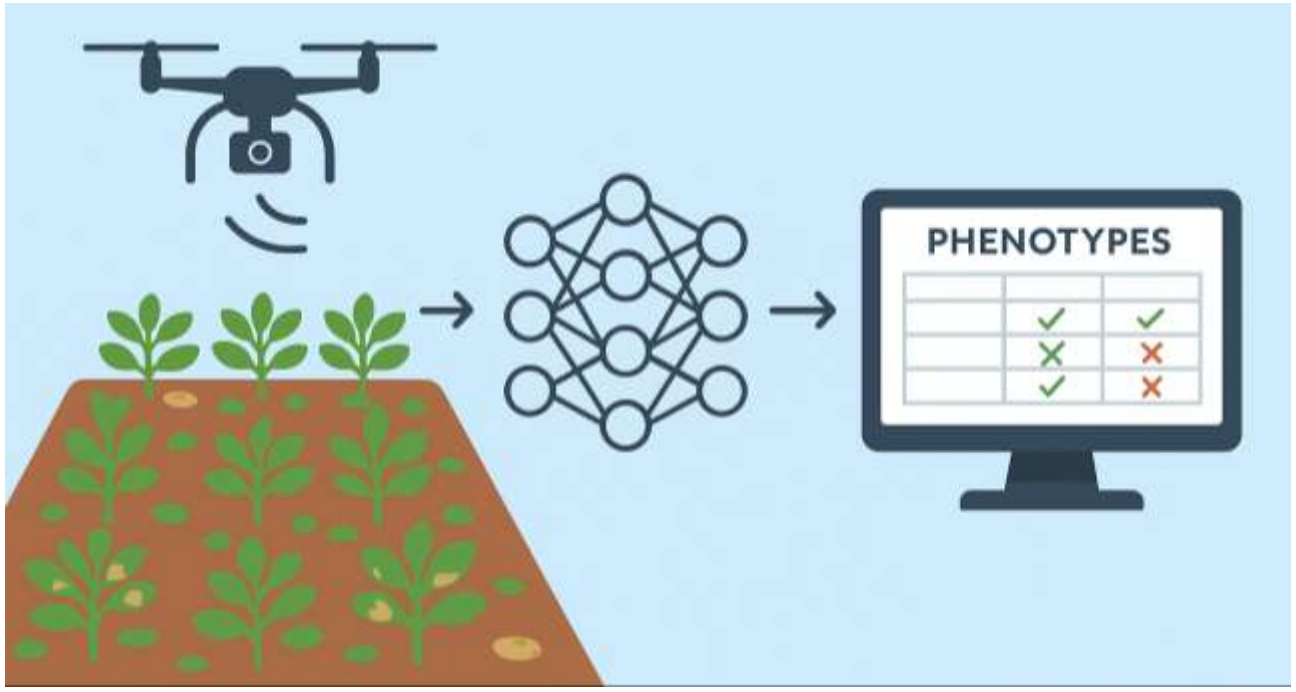


Fig 1: Experimental field design for year 2022

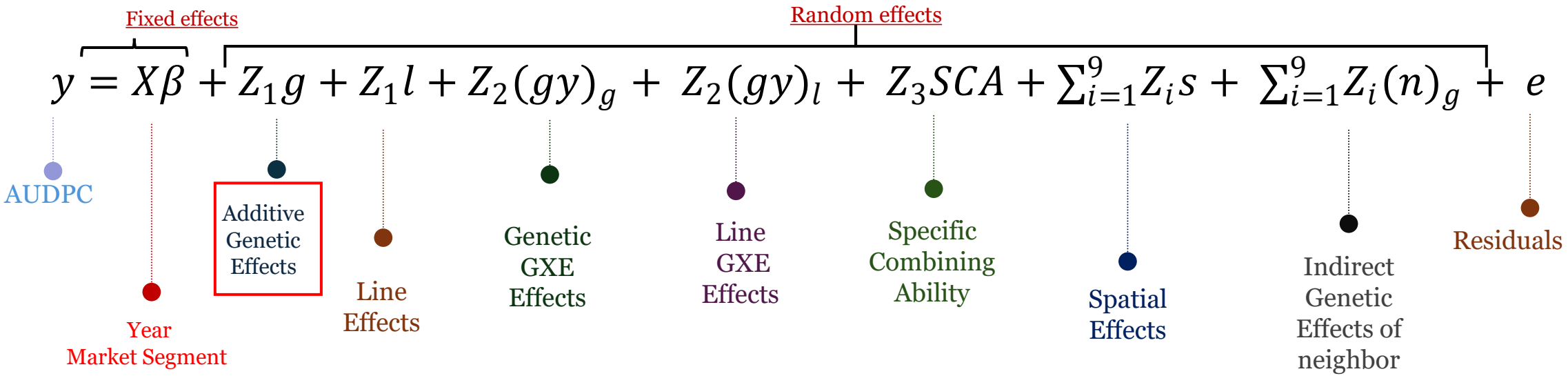
High Throughput Phenotyping System





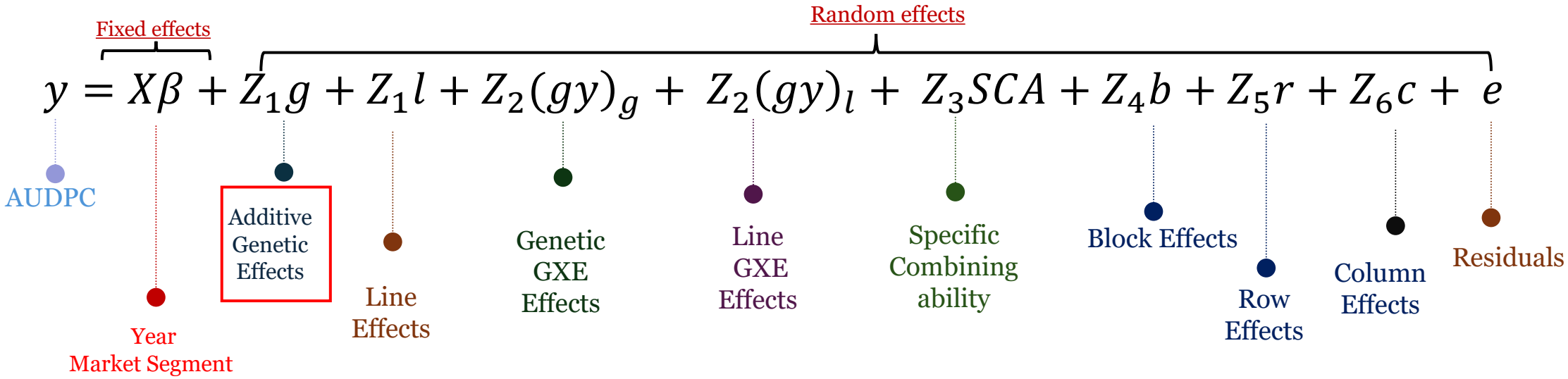
High Throughput Phenotyping

MODEL 1: Random Moving Means + Indirect Genetic Effects



ABLUP: $y = X\beta + Z_1 g + Z_2(gy)_g + Z_3 SCA + \sum_{i=1}^{9} Z_i s + \sum_{j=1}^{9} Z_j(n)_g + e$

MODEL 2: Row-Column Model



ABLUP: $y = X\beta + Z_1 g + Z_2(gy)_g + Z_3 SCA + Z_4 b + Z_5 r + Z_6 c + e$

Results: Variance Components

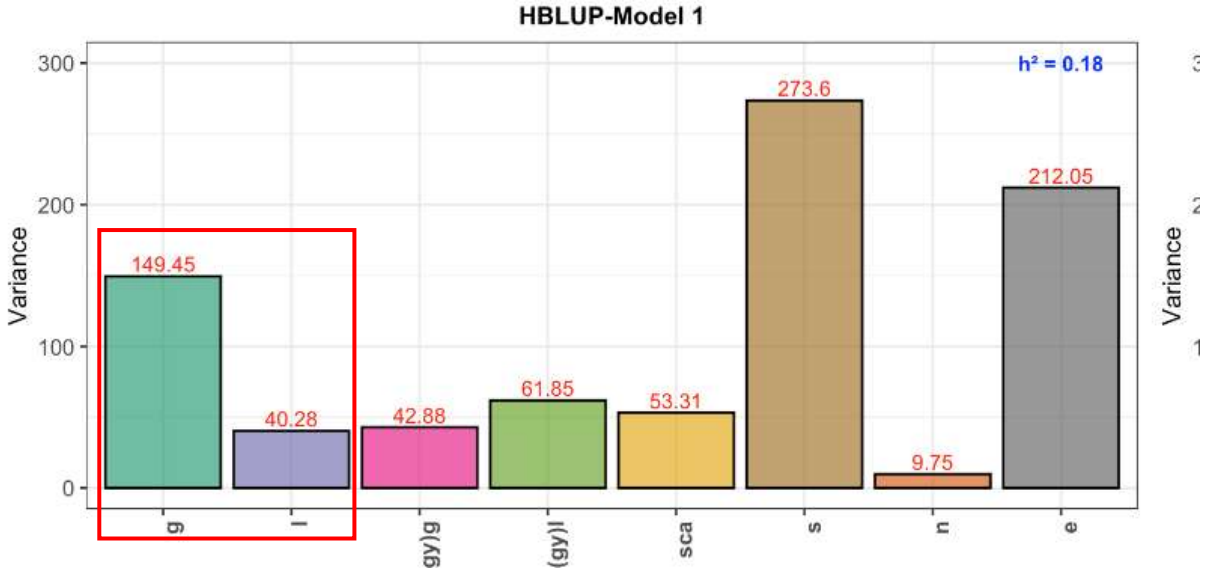


Fig 2. Estimated variance components for AUDPC of late blight of potato.

Table 3. Heritability of traits for different models.

Model	h^2_{ns}	$h^2_{\bar{y}_c}$
HBLUP Model 1	0.18	0.34
ABLUP Model 1	0.24	0.47
HBLUP Model 2	0.16	0.29
ABLUP Model 2	0.21	0.38

- ✓ Spatial Effects affects the disease score the most
- ✓ Genetic component also significantly influence late blight resistance

Accuracy of Prediction

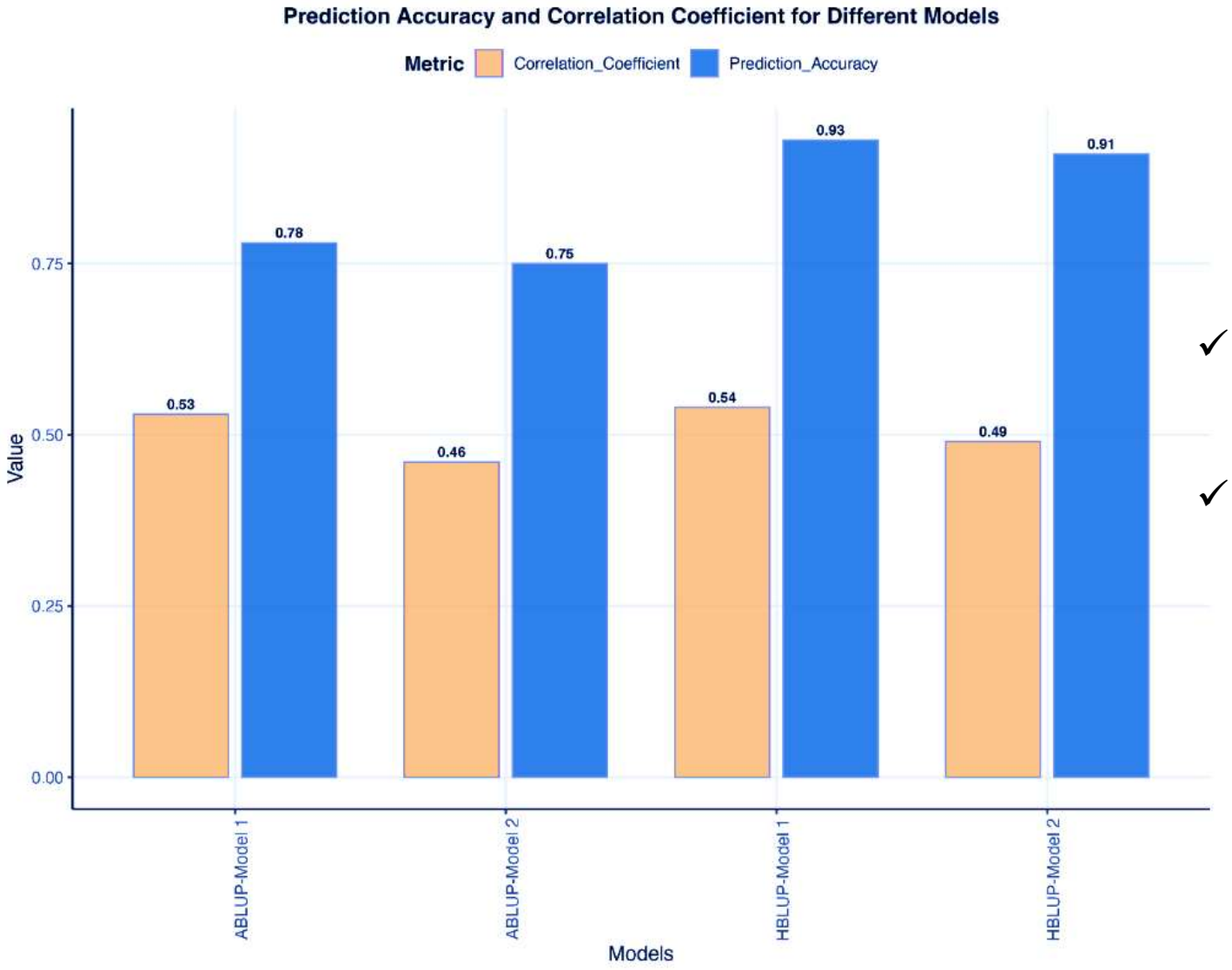


Figure 3. Accuracy of prediction across different models.

- ✓ Accuracy of prediction for late blight resistance ranged from 0.75-0.93
- ✓ Relatively higher accuracy of prediction

Genomic Selection

Y_0

Y_1

Y_2 (1 tubers) **Single Hill**

Y_3 (7 tubers) **Clone A**

Y_4 (49 tubers) **Clone B**

Y_5 **Clone C**

Y_6 **Clone D**

Prediction

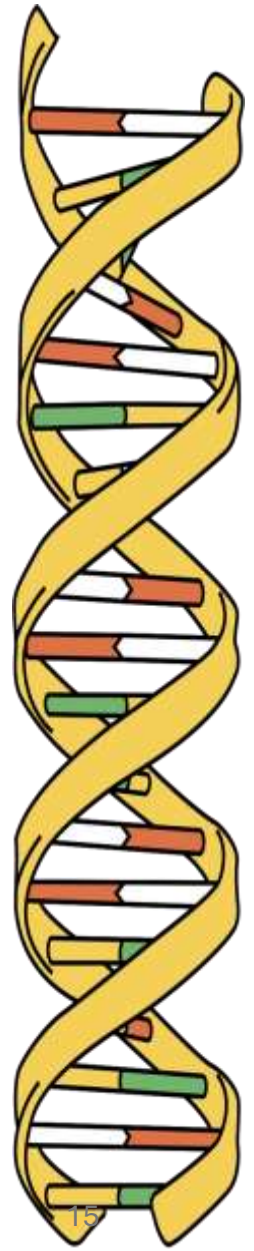
Genotype

Phenotype

Genomic Prediction Model

GEBV

Durable Resistance



5. Conclusions

- ✓ Late blight of potato: Globally the most destructive disease of potato
- ✓ Fungicide application remains common, but are increasingly unpopular and subjected to regulatory constraints
- ✓ Given the polygenic nature of the late blight, genomic selection could offer such a promising solution for developing resistance to late blight.
- ✓ Combining gene pyramiding with quantitative resistance may offer sustainable, high-level disease resistance.
- ✓ Even after 100+ years of breeding, truly durable resistance remains difficult to achieve.

7. References

Danan, Sarah, Jean-Baptiste Veyrieras, and Véronique Lefebvre. 2011. “Construction of a Potato Consensus Map and QTL Meta-Analysis Offer New Insights into the Genetic Architecture of Late Blight Resistance and Plant Maturity Traits.” BMC Plant Biology 11:16. doi:10.1186/1471-2229-11-16.

Poland, Jesse A., Peter J. Balint-Kurti, Randall J. Wisser, Richard C. Pratt, and Rebecca J. Nelson. 2009. “Shades of Gray: The World of Quantitative Disease Resistance.” *Trends in Plant Science* 14(1):21–29. doi:10.1016/j.tplants.2008.10.006.

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Paluchowska, Paulina, Jadwiga Śliwka, and Zhimin Yin. 2022. “Late Blight Resistance Genes in Potato Breeding.” *Planta* 255(6):127. doi:10.1007/s00425-022-03910-6.

Acknowledgements

Supervisor Committee

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Thank You...