Plant breeding for climatic adaptation

Docentship lecture

Elli Koskela

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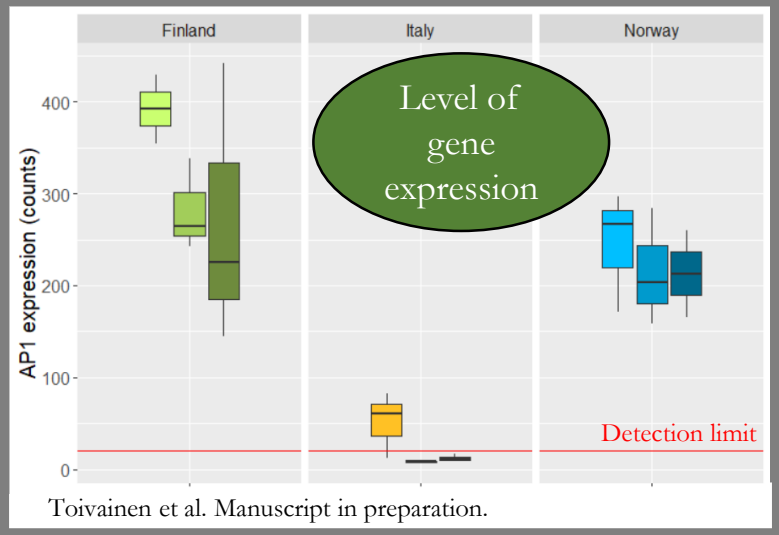
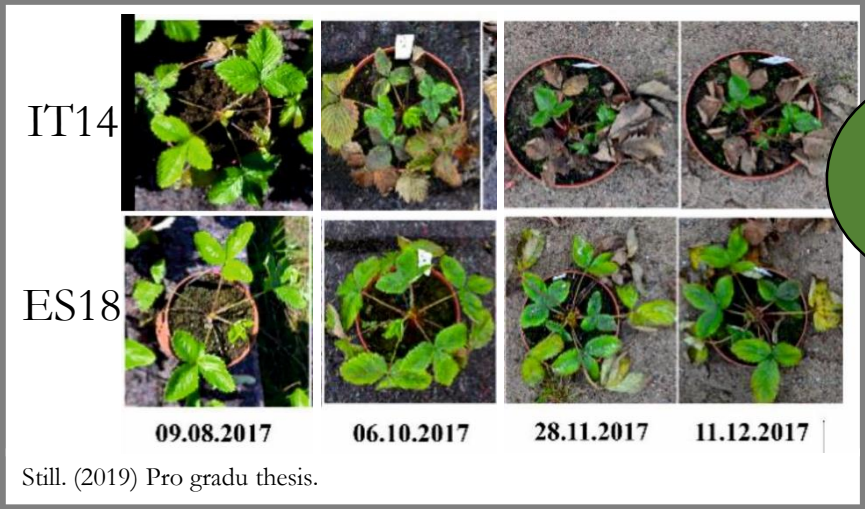
Lecture aims

- Revision of concepts:
  - Phenotype & genotype
  - Genotype x environment interaction
  - Heritability
- Learning a new concept:
  - Breeding aim
- Getting familiar with traits linked to climatic adaptation

What is a phenotype?



Toivainen et al. Manuscript in preparation.



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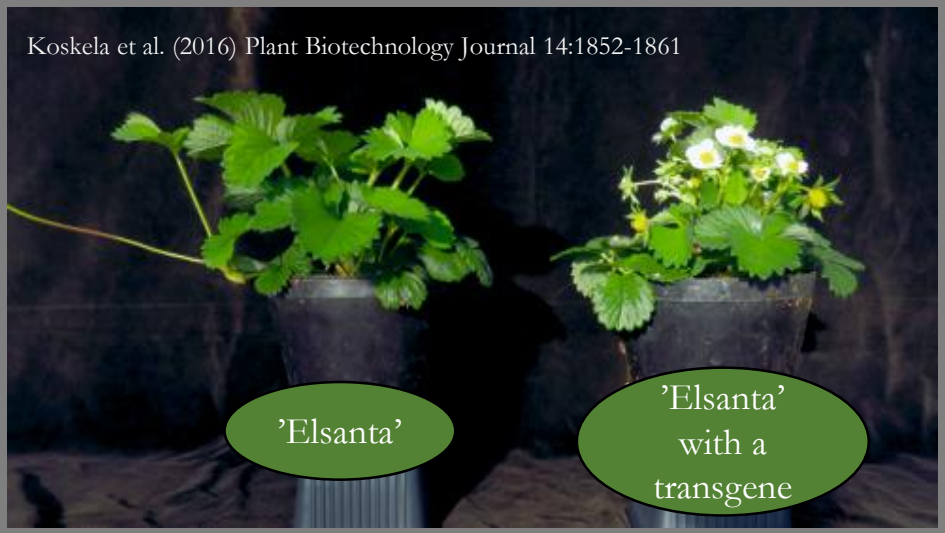
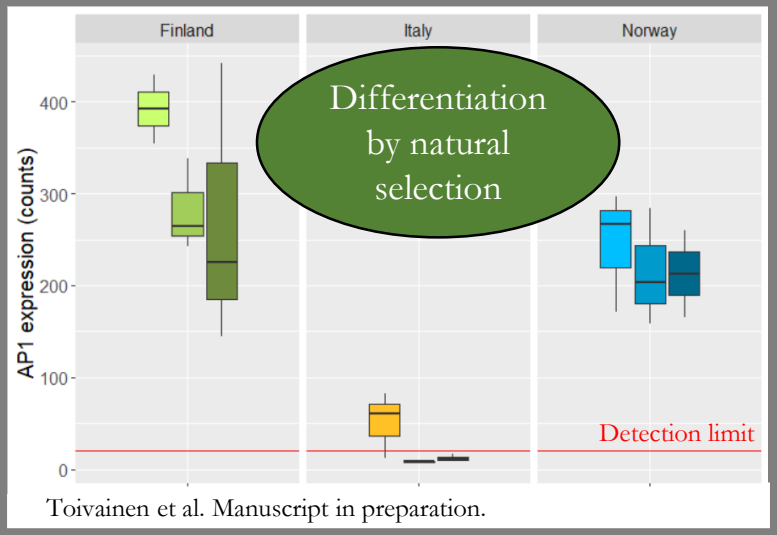
Phenotype is an observable and measurable characteristic of an organism

What is a genotype?





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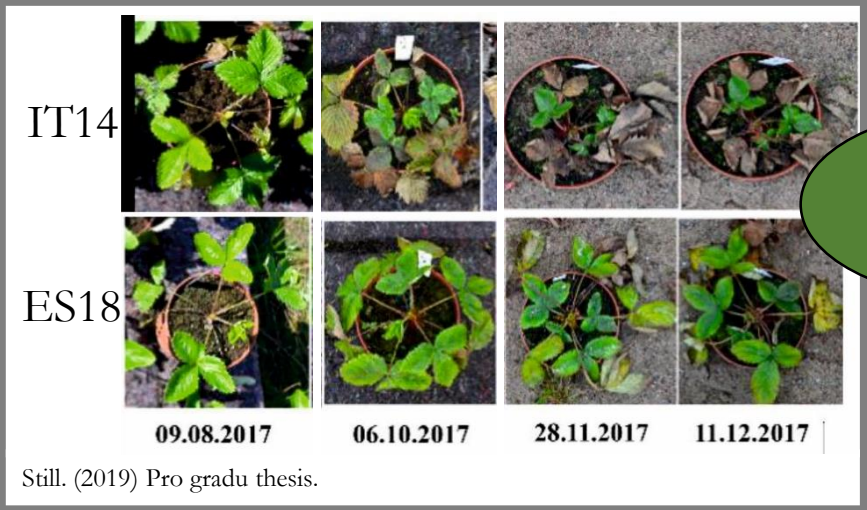

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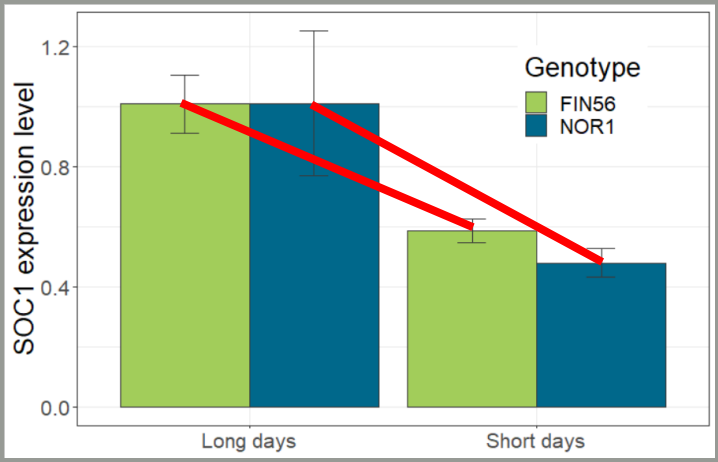
Genotype refers to the entire set of alleles that a plant possesses

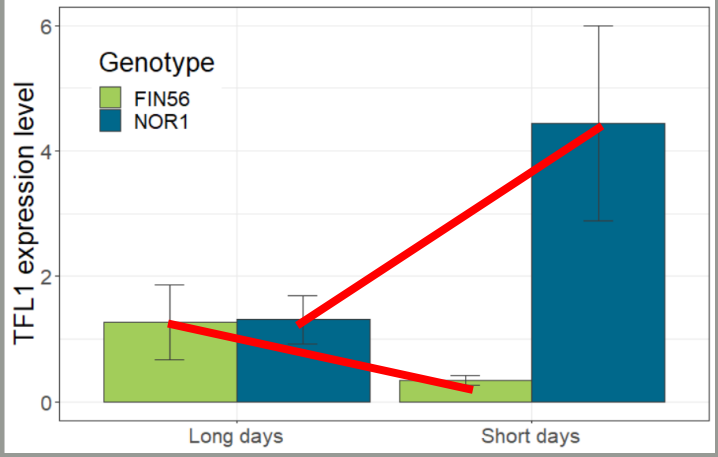
What is genotype x environment interaction?



Phenotype: *SOC1* expression

Photoperiod affects the expression level similarly in FIN56 and NOR1

No genotype x environment interaction



Phenotype: *TFL1* expression

FIN56: short days de-activate *TFL1*
NOR1: short days activate *TFL1*

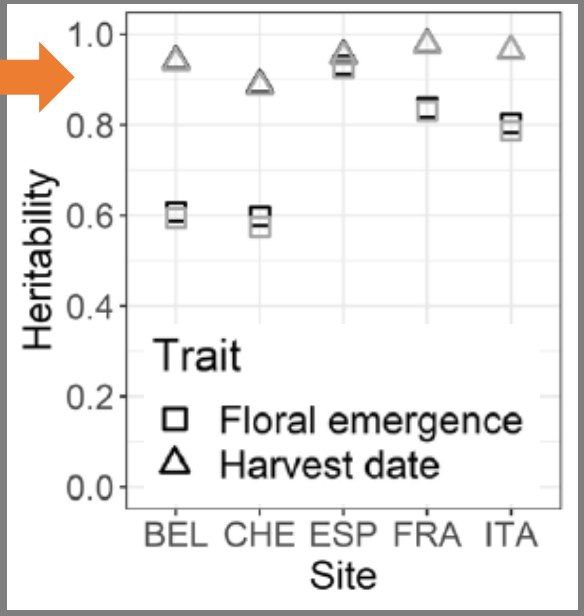
Genotype x environment interaction!

Koskela et al. (2017) New Phytologist, doi: 10.1111/nph.14734

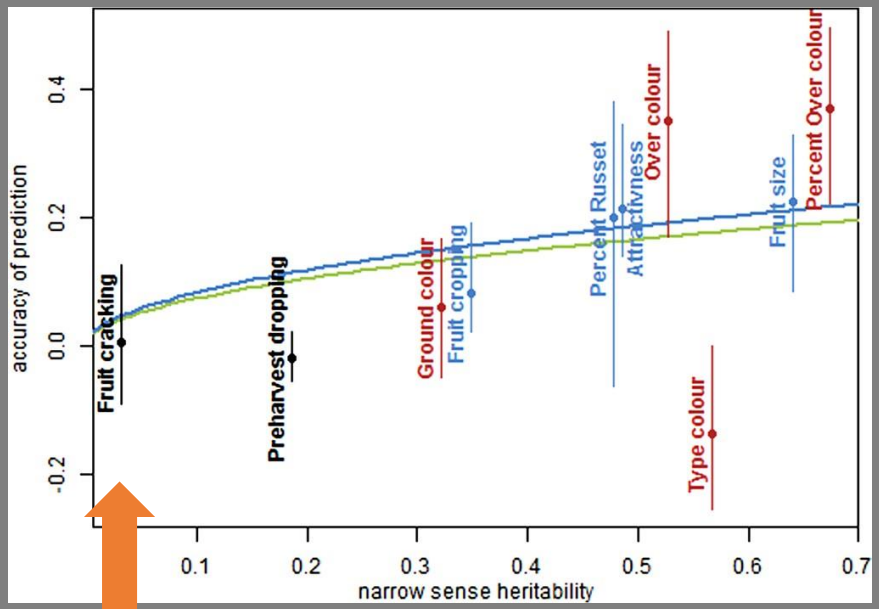
What is heritability?

- Narrow-sense heritability: ratio of additive genetic variance to total phenotypic variance

- Heritability estimates are specific to the population and environment

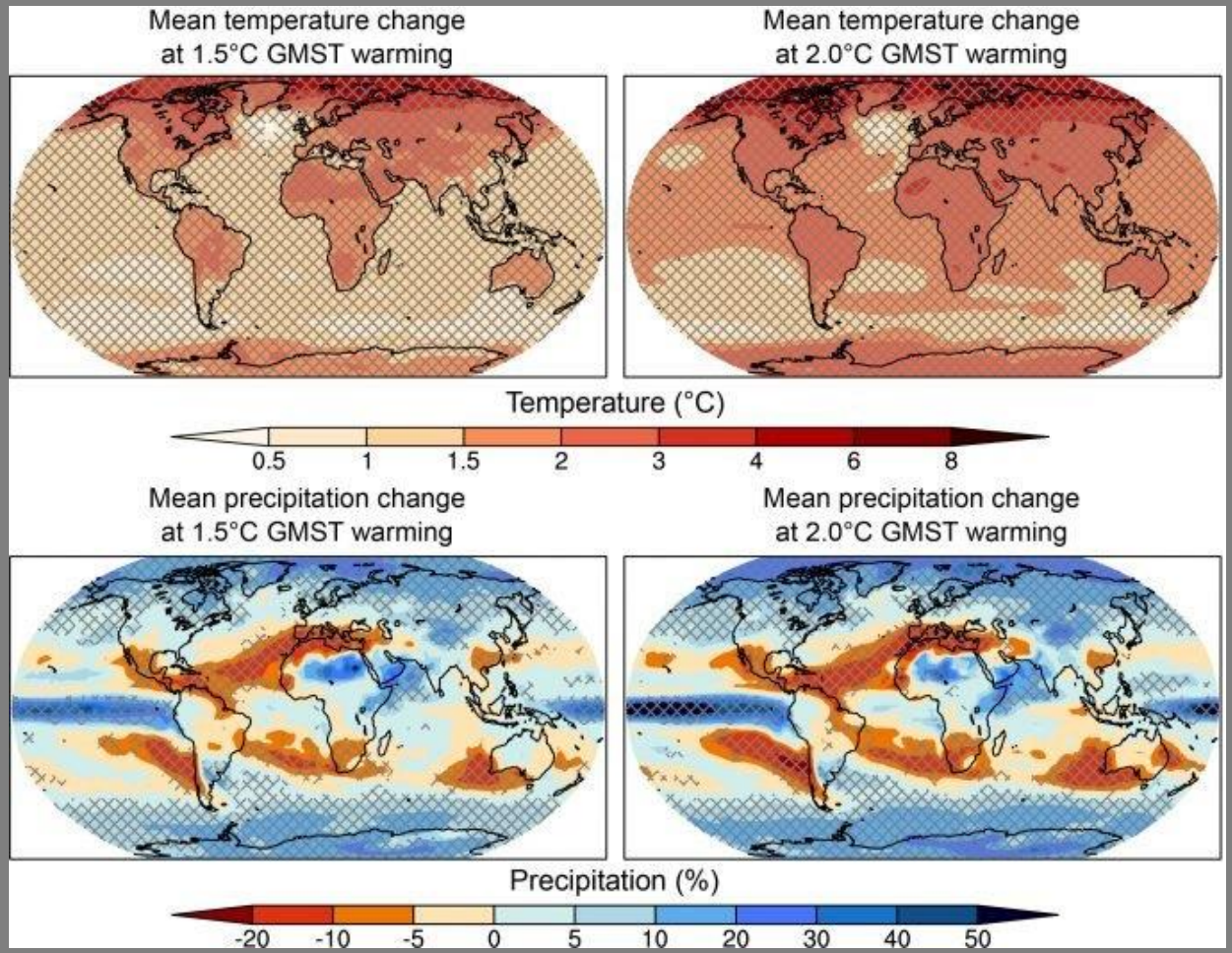


Jung et al. (2020) Horticulture Research, doi:10.1038/s41438-020-00408-8



Muranty et al. (2015) Horticulture Research, doi:10.1038/hortres.2015.60

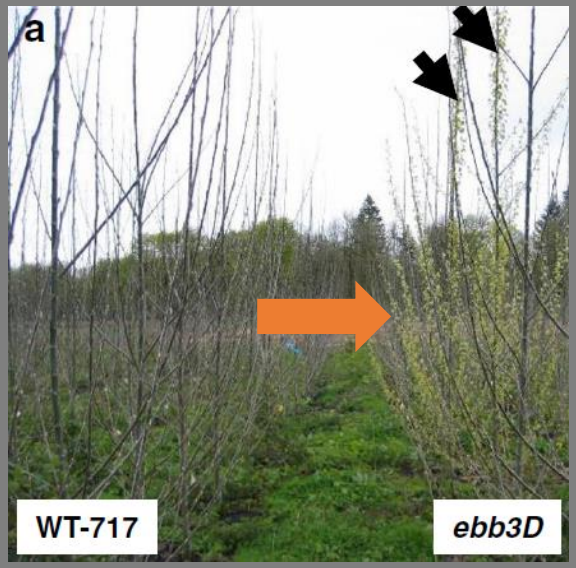
Preparing for climate change..



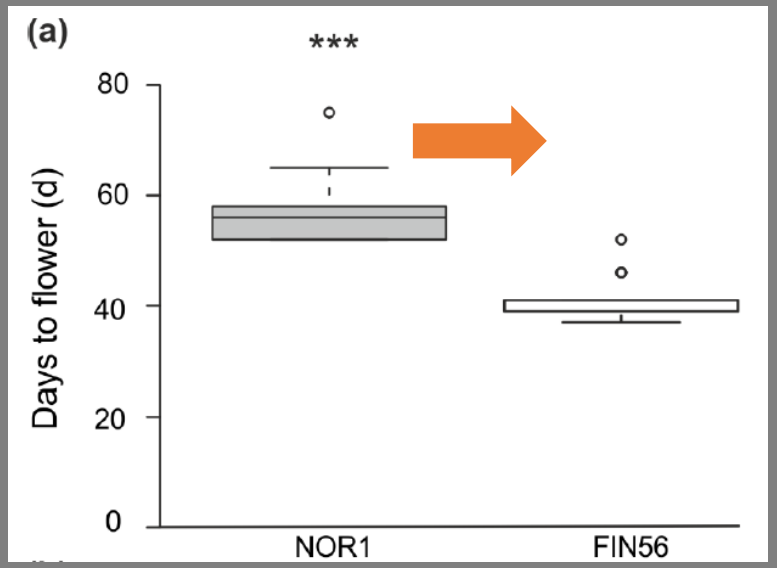
Hoegh-Guldberg OD. Jacob, M. Taylor, M. Bindi, S. Brown, I. Camilloni, A. Diedhiou, R. Djalante, K.L. Ebi, F. Engelbrecht, J. Guiot, Y. Hijioka, S. Mehrotra, A. Payne, S.I. Seneviratne, A. Thomas, R. Warren, and G. Zhou, 2018: Impacts of 1.5°C Global Warming on Natural and Human Systems. In: *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty* [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. In Press.

Breeding objective

- Breeding objective is set before planning or executing a breeding project
- Breeding objective = the goal



Azeez et al. (2021) Nature Comunications, doi: 10.1038/s41467-021-21449-0



Koskela et al. (2017) New Phytologist, doi: 10.1111/nph.14734

Breeding objective: measurability

Measurable trait!

- kg/ha, µg/g, cm…
- Percentage (flowering plants, open buds…)
- Days to an event
- Binary trait

Feasibility of measuring?

Still. (2019) Pro gradu thesis.

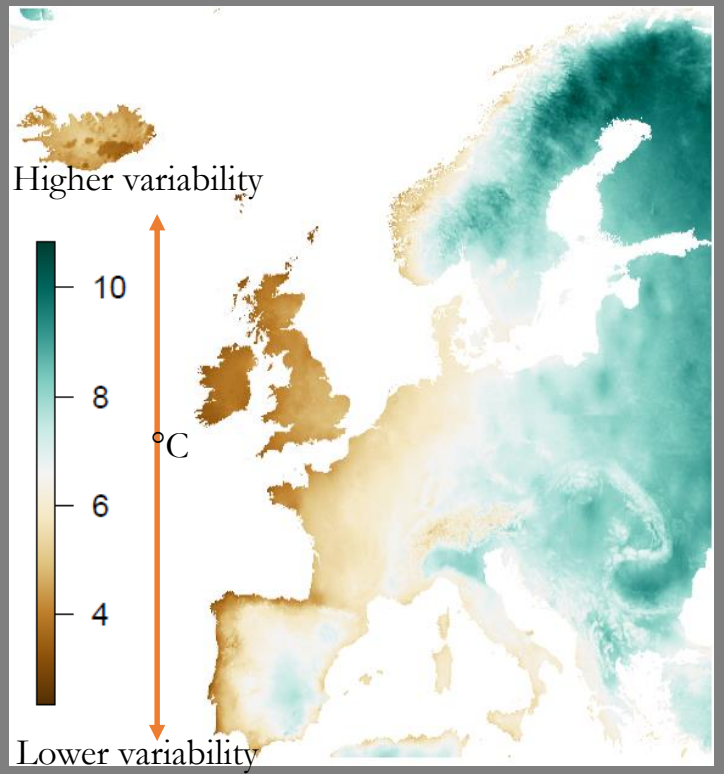
Azeez et al. (2021) Nature Comunications, doi: 10.1038/s41467-021-21449-0

Breeding objective: specificity

Specificity in terms of..

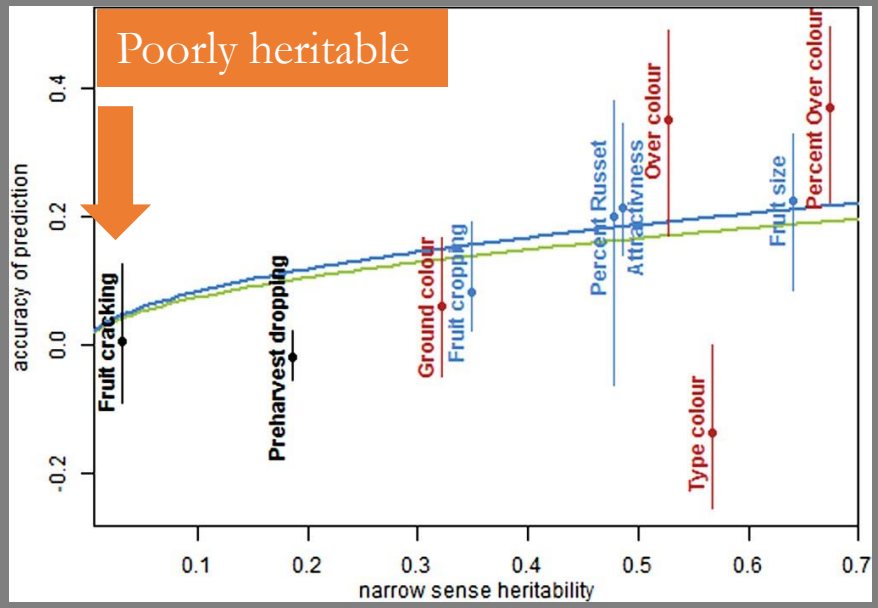
- Phenotype + desired effect
- Intended / expected growing environment

Specificity is a consequence of the testing environment!



Temperature seasonality = amount of yearly temperature variation based on standard deviation of monthly mean temperatures
Figure by Sergei Suprun

Breeding objective: attainability



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Difficult when..

- No trait variation within the available gene pool
- Trait variation available, but in very exotic germplasm
- Trait has low heritability

Feasible breeding target

Trait	Measurable?	Specific?	Attainable?
Reliably high apple yield in all climatic conditions	Yes (kg/ha)	Not in terms of climate	No
Late flowering in strawberry in Scandinavia	Yes (Days to flower)	Yes	Yes
Resistance to apple fruit cracking	Yes (Occurrence of cracks)	Yes	No (low heritability)

Thank you for your attention!

Questions?