

The effects of natural and artificial selection on seedling traits in Scots pine (*Pinus sylvestris*)

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Models of clinal variation assume stabilizing selection with different optima within each population. Scots pine has strong latitudinal clines in many traits (e.g., Avia *et al.* 2014, Kujala, Knürr *et al.* 2017).

? How does natural selection shape variation in clinally varying seedling traits within population? ?

Artificial selection on height (tree breeding) has resulted in genetic improvement in growth for 15-25 year old trees (Ahtikoski *et al.* 2012, Haapanen *et al.* 2016).

? Has the artificial selection resulted in changes in correlated traits (not directly selected for) such as ? timing of bud set or cold tolerance? ?

Seedling traits measured in a greenhouse experiment 2008.

500 half sib families from a natural forest stand, 24 seedlings per family.

10 seedling per family were transferred to field > fitness (survival and height) measured in 2017.



Figure 1: green: origin of the natural population & location of the field trial; pink: origins of the breeding material; star: greenhouse.

Seedling traits measured in a greenhouse experiment 2018.

80 full sib families from breeding population, 35 seedlings per family.

60 half sib families from a natural forest stand, 35 seedlings per family.

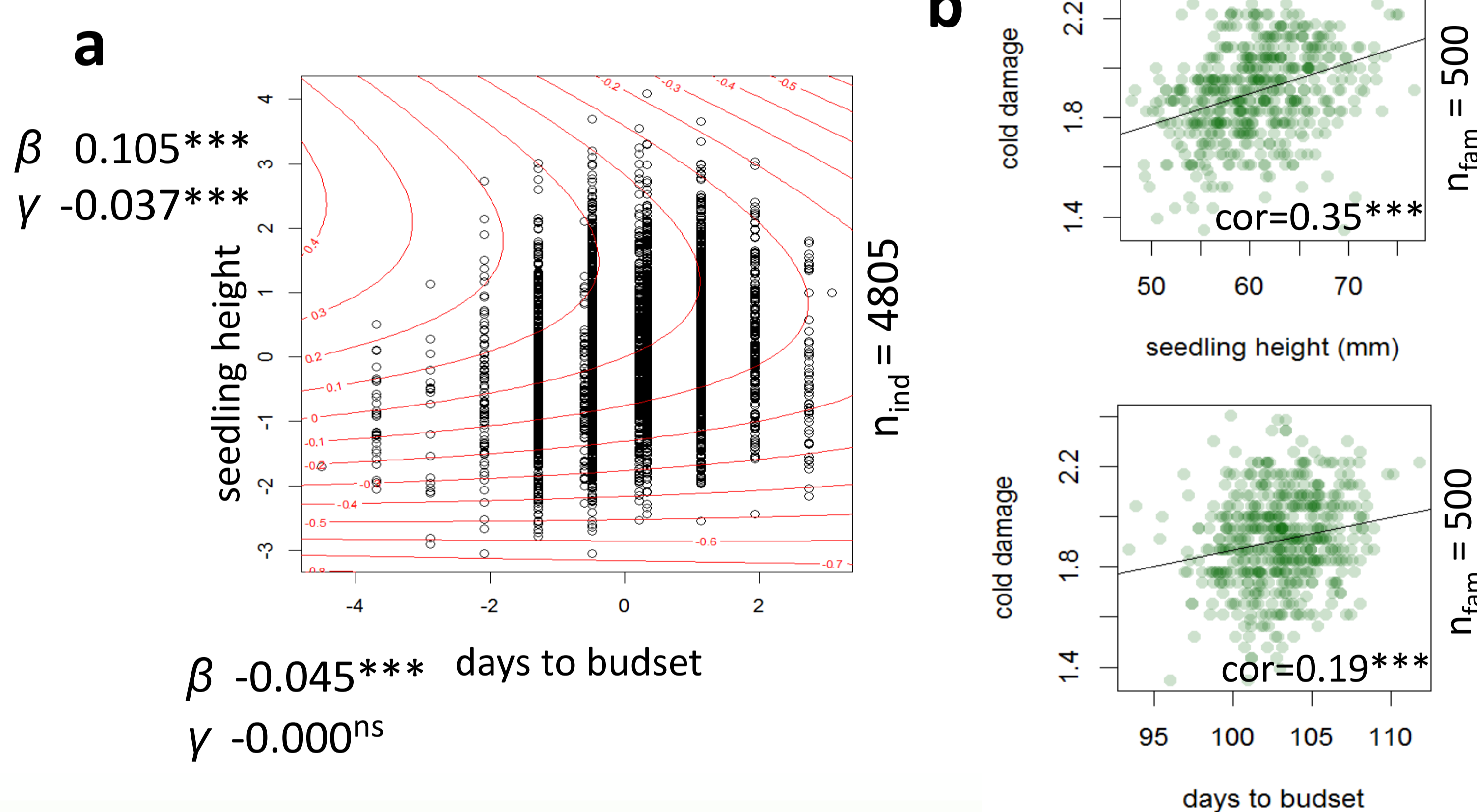


Figure 2: **a)** Selection analysis using Aster (Geyer *et al.* 2007): fitness from aster model (red contours) related to standardized seedling traits. **b)** Correlation of cold damage with timing of bud set and seedling height (at family level).

- Natural selection favors taller seedlings, even if they are more prone to cold damage in the early years (both directional and stabilizing selection indicated)
- Natural selection favors earlier timing of bud set, even if that reduces height. Stabilizing selection not seen within this data.
- Southern-biased gene flow likely brings in "late" alleles and "tall" alleles.
- Complex interplay of selection on correlated traits coupled with gene flow may influence maintenance of clines.
- In predicting climate change responses, selection on correlated traits may be important.

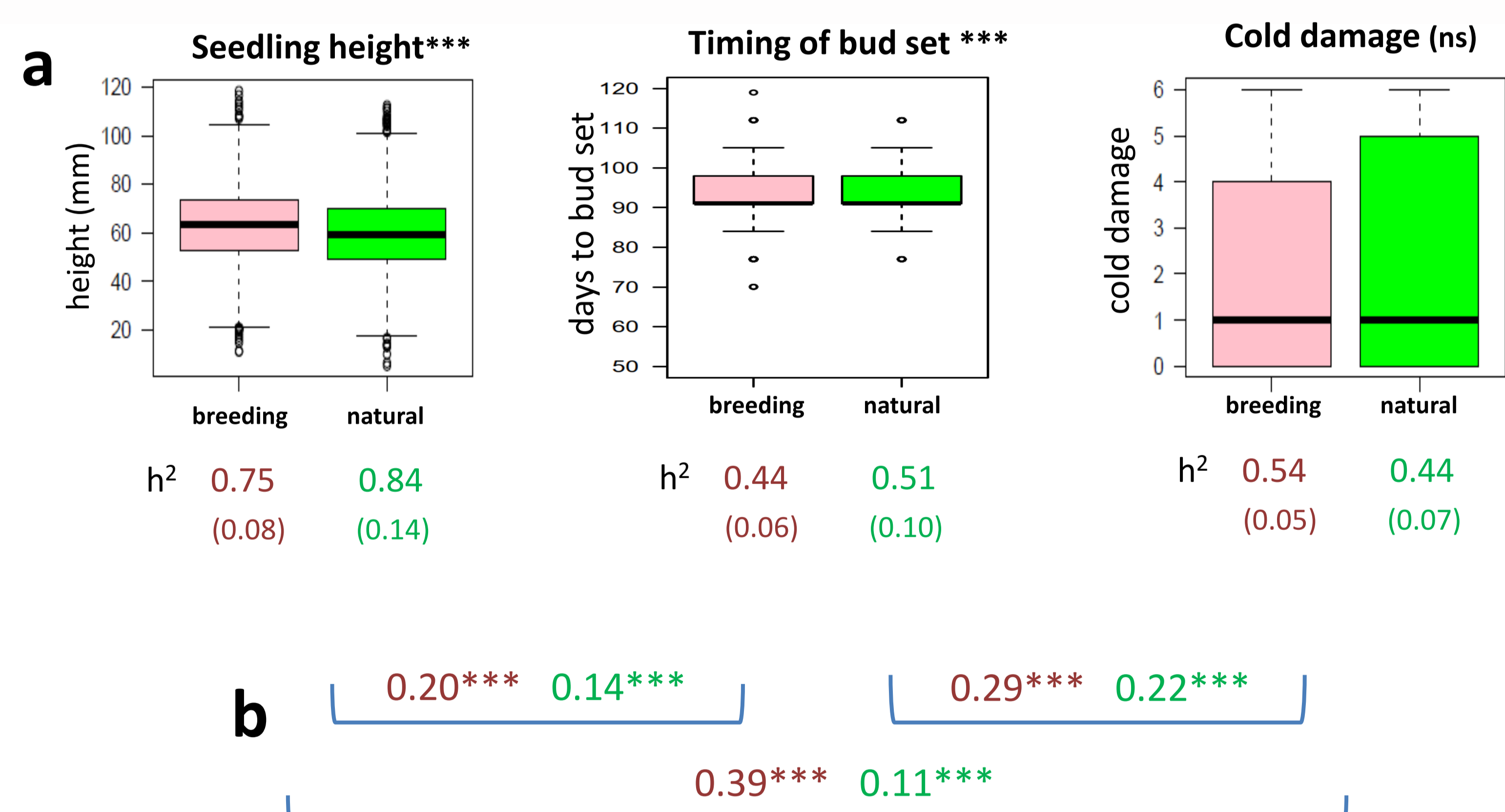


Figure 3: Comparison of breeding (pink) and natural (green) populations. **a)** Distributions of seedling traits. Significance of difference in population means indicated with stars. Narrow sense heritabilities (standard error) below. **b)** Correlations of individual seedling BLUPs between traits.

- Seedlings of selected plus trees are slightly taller than progeny of natural population
- Improved seedlings set buds slightly (~1 day) earlier than natural seedlings.
- Breeding population has higher trait correlations than the natural population.
- Greater growth of breeding material is not a result of lengthening the annual growth period.
- At this stage it should be possible to breed for increased height without losing cold tolerance.