Bioenergy from winter beet
– a joint project along the value chain -

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Factors affecting the winter hardiness of sugar beet

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Introduction

The cultivation of winter sugar beet can contribute to a marked yield increase compared to spring sown beets. Sown in August, the plants have to survive frost temperatures in winter. For survival, the environmental conditions during winter (minimum temperature), but also plant development and composition may play a role. The objective of the study was to analyze factors affecting the survival rate of sugar beet plants.

Material & Methods

Field trials:
- 11 environments (4 years,3 loc)
- 5 genotypes

Greenhouse experiments:
- 1 genotype
- controlled conditions for acclimatization and frost
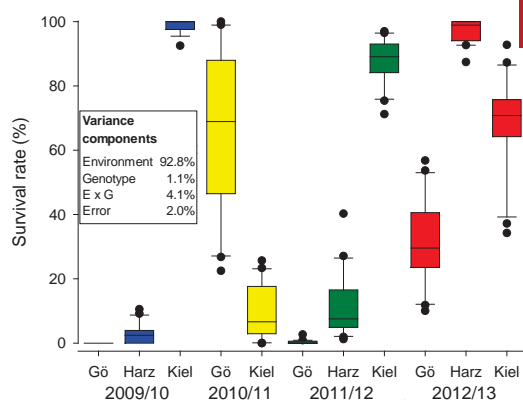
Results

Fig. 1: Survival rate of 5 autumn sown sugar beet genotypes after winter, 3 locations, 4 years; E = environment, G = genotype
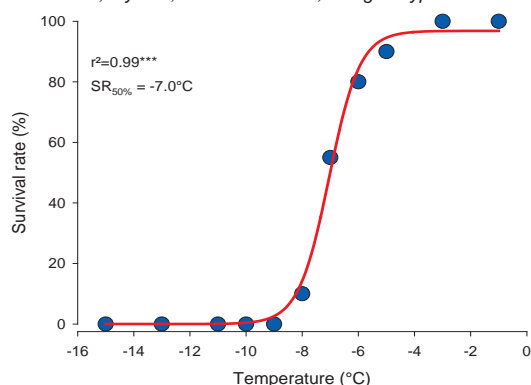

Fig. 2: Survival rate (SR) of sugar beet as affected by temperature, 2 greenhouse experiments, mean of 10 replicates; growing for 10 weeks at 20 °C, 2 weeks acclimatization at 4 °C, then controlled frost stress
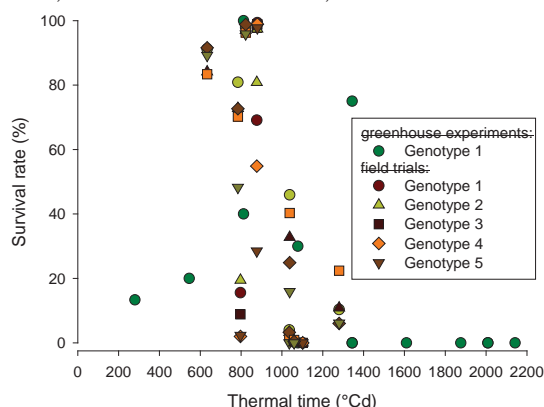

Fig. 3: Survival rate of autumn sown sugar beet as affected by thermal time until a frost incidence of -7 °C, 3 greenhouse experiments, field trials in 11 environments 2009/10-2012/13

Tab. 1: Correlation of the survival rate of sugar beet genotypes after winter with different compounds in taproot and leaves determined in Oct./Nov. 4 field trials (Göttingen, Kiel, 2010 and 2012), 5 genotypes, sowing in August; relative values standardized to the mean of each location

Composition	Spearman's correlation with survival rate			
	Taproot		Leaves	
	- Coefficient of correlation -			
DM conc. (%)	0.36	**	0.42	***
Osmolality (mOsmol kg⁻¹ FM)	0.27	*	0.50	***
Potassium (mmol kg⁻¹ FM)	0.13	n.s.	0.36	**
Sodium (mmol kg⁻¹ FM)	0.19	n.s.	0.28	*
Sucrose (mmol kg⁻¹ FM)	0.13	n.s.	0.12	n.s.
Raffinose (mmol kg⁻¹ FM)	-0.59	***	0.18	n.s.
Amino-N (mmol kg⁻¹ FM)	0.27	*	0.37	***
Betaine (mmol kg⁻¹ FM)	0.53	***	0.65	***
Glutamine (mmol kg⁻¹ FM)	0.23	*	0.25	*
Proline (mmol kg⁻¹ FM)	-0.02	n.s.	-0.12	n.s.

* = $p \le 0.05$; ** = $p \le 0.01$; *** = $p \le 0.001$; n. s. = not significant

Conclusions

- High variation of the survival rate of sugar beets after winter
- Effect of the environment is markedly higher than the genotype effect
- Minimum temperature for sugar beet plants is between -6 and -8 °C
- Survival rate after winter depends largely on the growth stage of plants before winter
- Optimal growth stage for maximum winter hardiness is reached after 600-900 °C days
  ⇒ calculation of the optimal sowing date
- Genotypes with high concentrations of DM, betaine, amino acids and osmolality showed higher survival rates
  ⇒ selection for improved winter hardiness

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