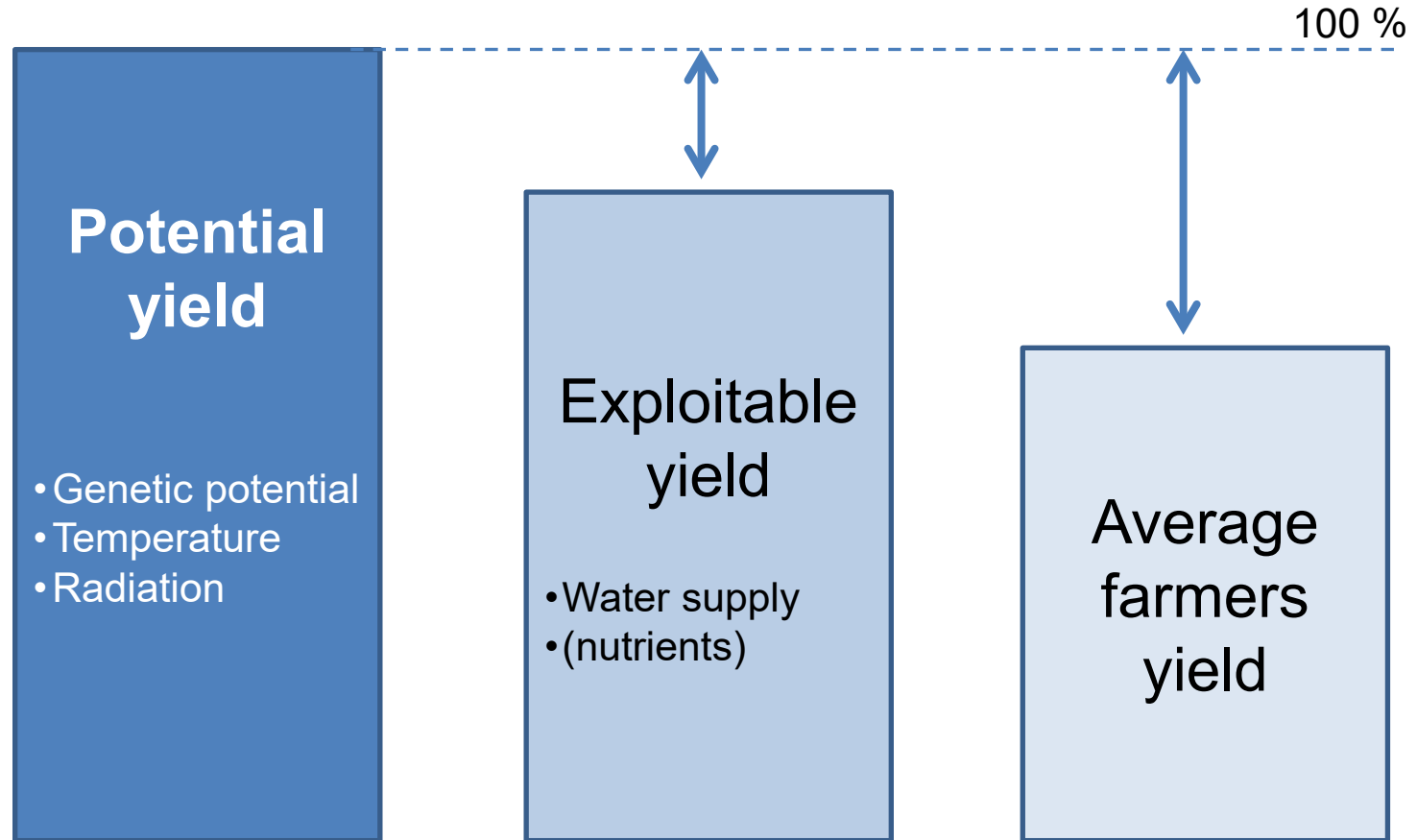# Potential sugar production for the beet crop
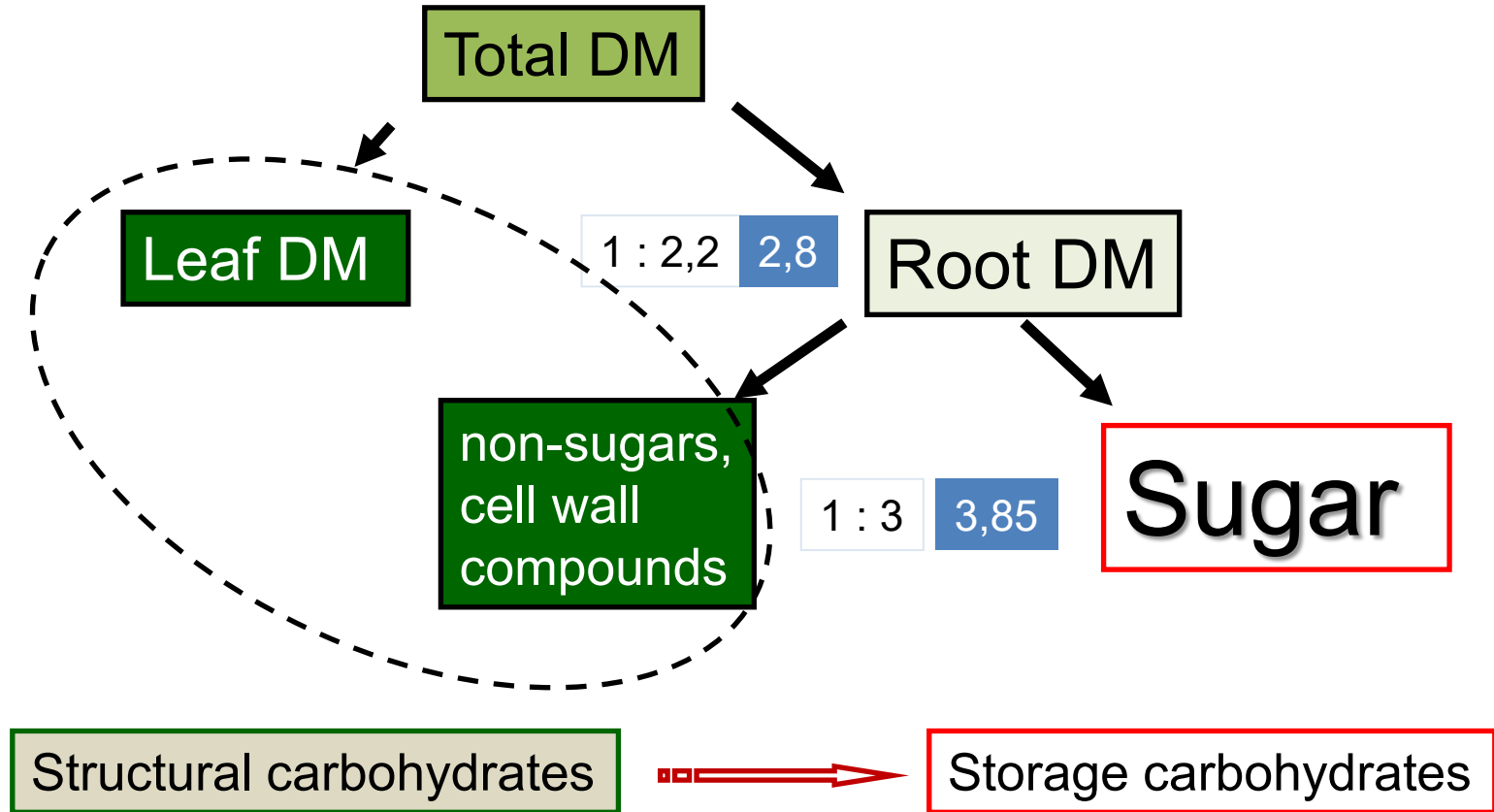
Prof. Dr. Christa Hoffmann

Institute of Sugar Beet Research

Göttingen, Germany

Potential yield and limitations

Potential yield

- Genetic potential
- Temperature
- Radiation

Exploitable yield

- Water supply
- (nutrients)

Average farmers yield

100 %

Genetic potential:
improved assimilate partitioning in sugar beet

Total DM

Leaf DM

1 : 2,2   2,8

Root DM

non-sugars, cell wall compounds

1 : 3   3,85

Sugar

Structural carbohydrates → Storage carbohydrates

Data from field experiments 2012-14

Hoffmann & Kenter 2018
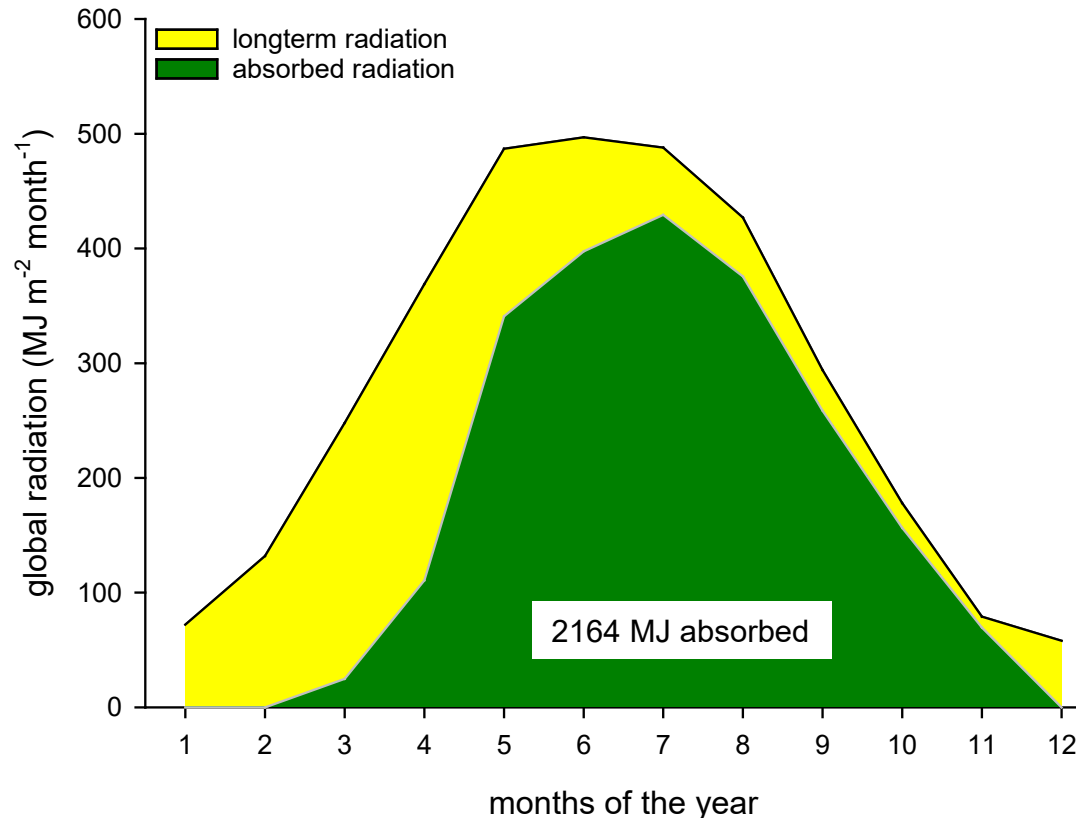
3

Light capture of sugar beet
calculated from the long-term average global radiation in Göttingen 1952-2014
assumption: 8% reflexion (Gates 1965); 10 % transmission (Monsi 1953)

- Complete canopy cover in times of high radiation
- Min temperature for growth: 3°C
- Growth and development is accelerated with higher temperature
- Early development is important for high light interception
- Optimum temperature for root growth: 18-20°C mean daily temperature

Potential sugar yield

calc. from light interception and conversion of light energy into biomass (RUE)

assumptions: root DM from total DM: 0.73, sugar from root DM: 0.77

Light interception ($MJ\ m^{-2}\ year$)	Conversion coefficient ($g\ DM\ MJ^{-1}$)	Total DM ($t\ ha^{-1}$)	Sugar ($t\ ha^{-1}$)
2000	1.4[#]	28.0	15.7
2400	1.4	33.6	18.9
2000	1.8[*]	36.0	20.2
2400	1.8	43.2	24.3
2000	**2.2**	44.0	24.7
	2.2		29.7

Long growing period, fast canopy closure

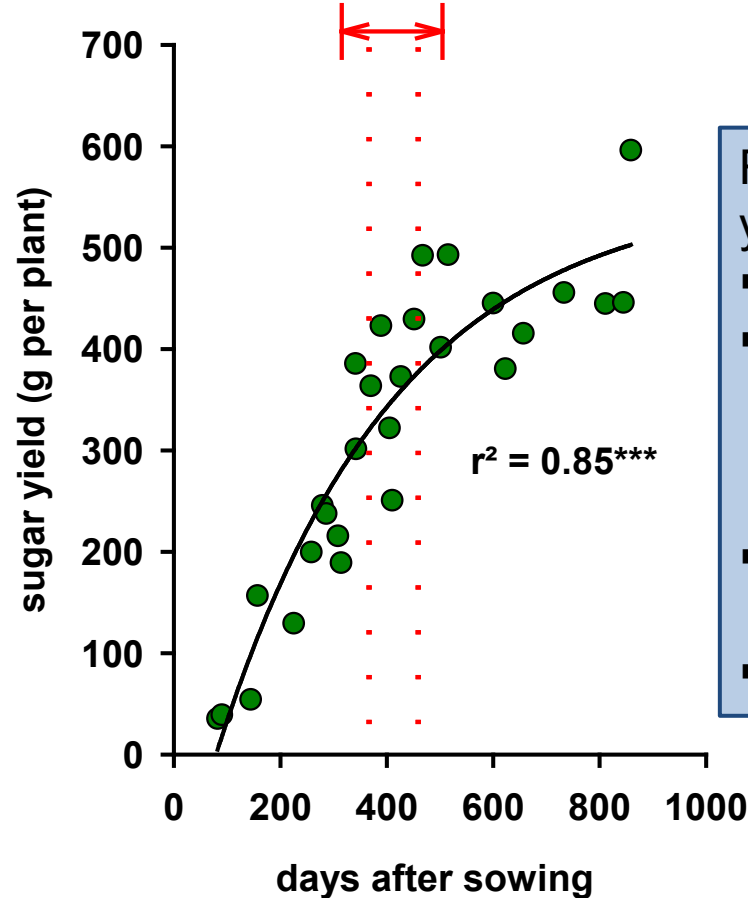Efficient conversion of light (RUE)

Kluge-Severin   2005

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Sugar yield after extending the growing period
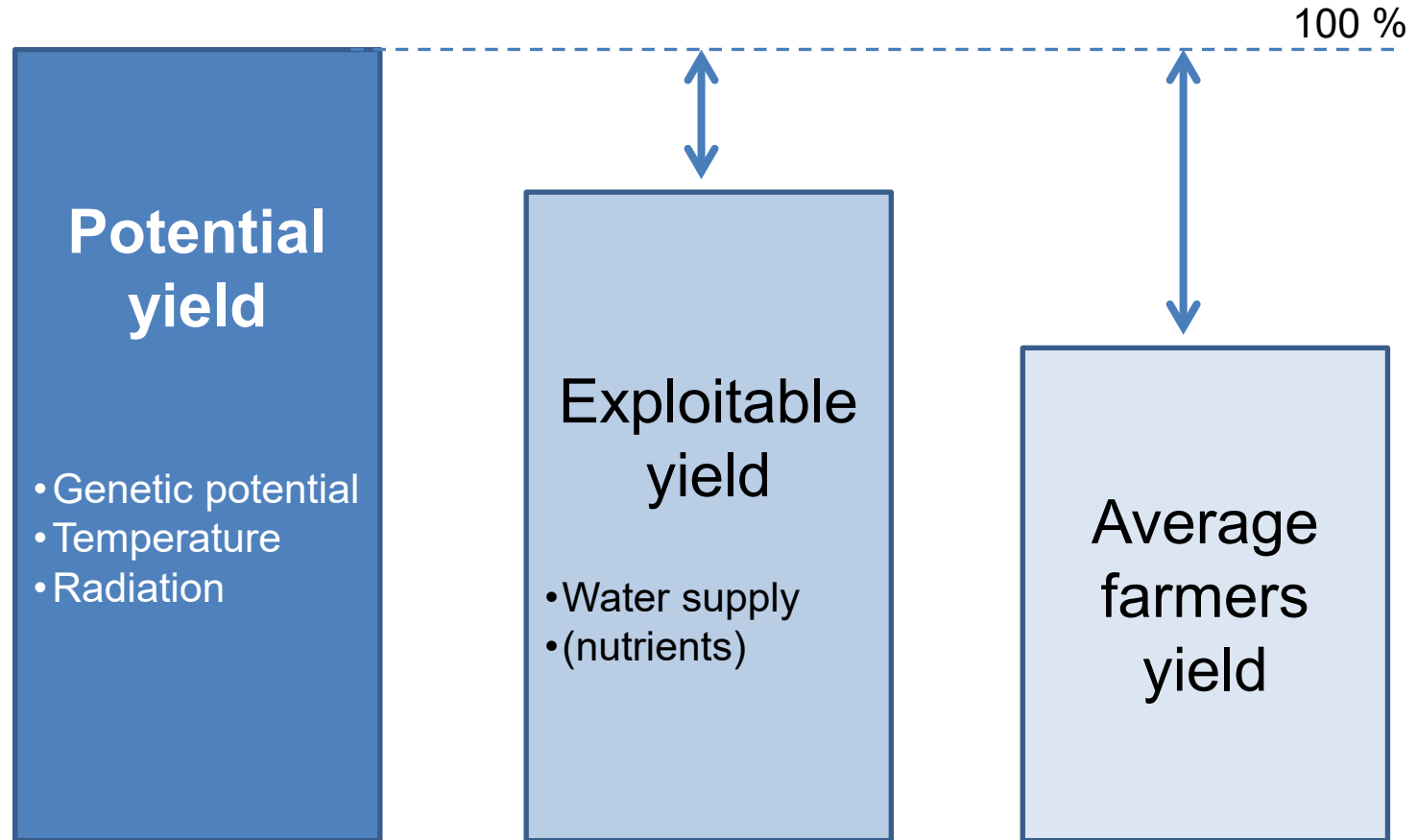pot experiment in the greenhouse, 11 sowing dates with 4 harvest dates, 15-22 °C

Further growth and sugar yield increase, but:
- Yield increment declines
- Changes in shape and composition
(less sugar, higher non-sugar cont)

- Beet not bolting and frost resistant
- Harvest conditions?

Schnepel & Hoffmann 2016

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Potential yield and limitations

100 %

Potential yield

- Genetic potential
- Temperature
- Radiation

Exploitable yield

- Water supply
- (nutrients)

Average farmers yield

Water demand – a relation to growth rates

Pot trials 2019 + 2020, greenhouse, growth 219 or 192 days, mean of 4 genotypes, 15-22 °C
5 repl., control treatment 100 % WHC = unlimited water supply
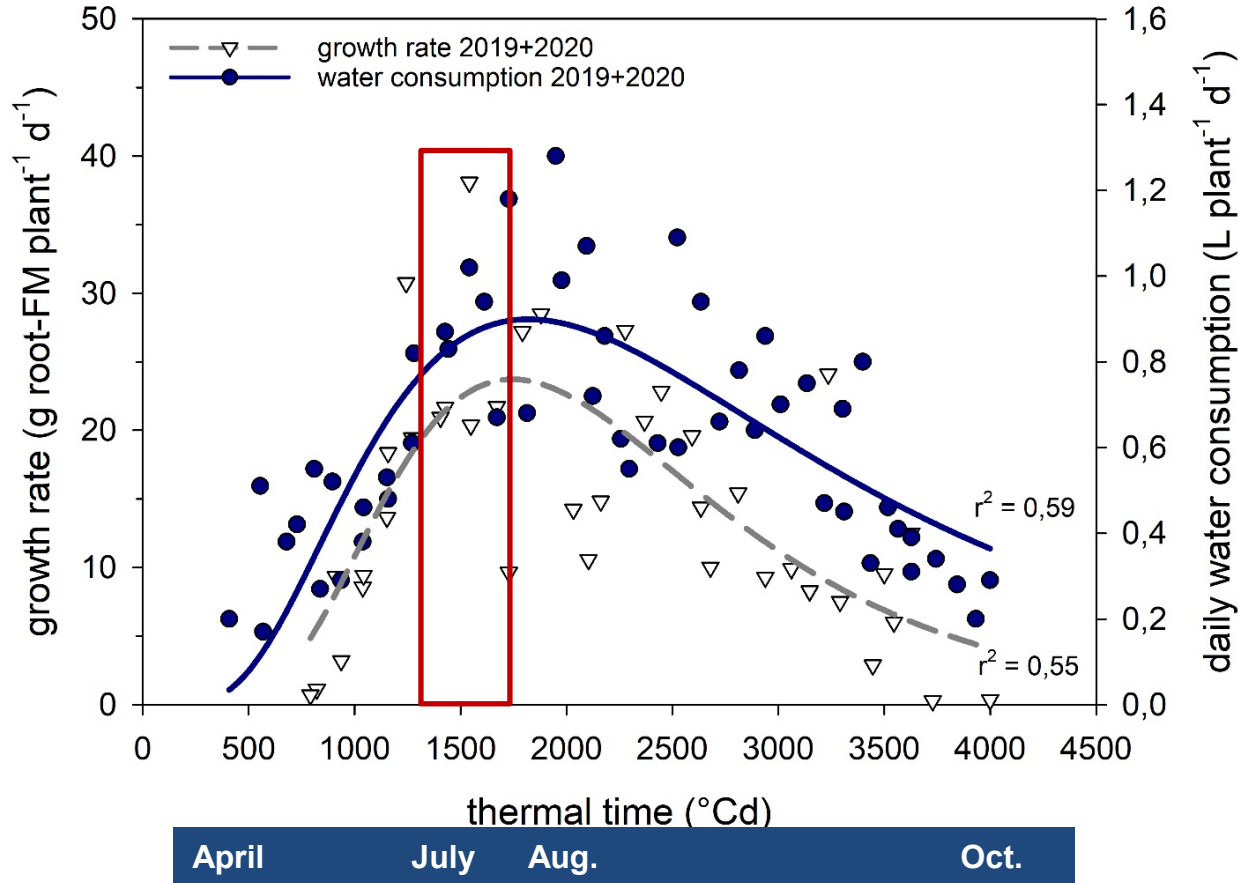
- water demand is driven by growth rates
- Highest water demand when growth is most intense

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Effect of drought stress periods on root growth

Pot trial in the greenhouse, 4 water supply treatments, mean of 4 genotypes, 5 repl., drought treatment ≙ 50 % of WHC for 4 weeks, control treatment ≙ 100 % WHC
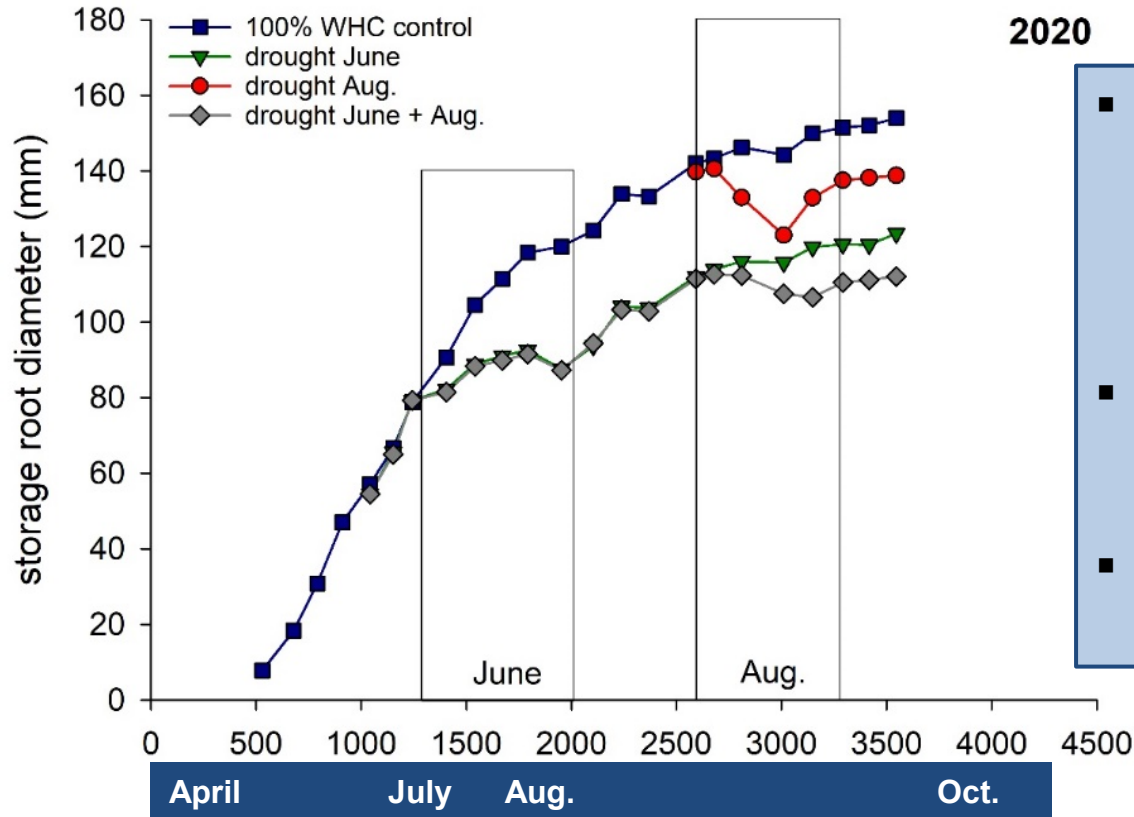
- Greatest effect of water shortage in phases of most intense growth: early summer
- No compensation of growth reductions later
- No lasting disruption of growth processes

Ebmeyer & Hoffmann 2021   9

Calculated water demand
for a high yielding sugar beet crop

assumptions: transpiration coefficient: 200 l H_2O /kg DM (Ehlers 1992, Hoffmann 2014)
sugar from root DM: 0.77, root DM from total DM: 0.73

Sugar yield (t/ha)	Root DM yield (t/ha)	Total DM yield (t/ha)	Water demand (mm/year)
18	23.4	32.0	640
20	26.0	35.6	712
22	28.6	39.1	783
24	31.2	42.7	854

Efficient DM partitioning
$\Rightarrow$ less leaf DM

Efficient water use
$\Rightarrow$ more sugar from water
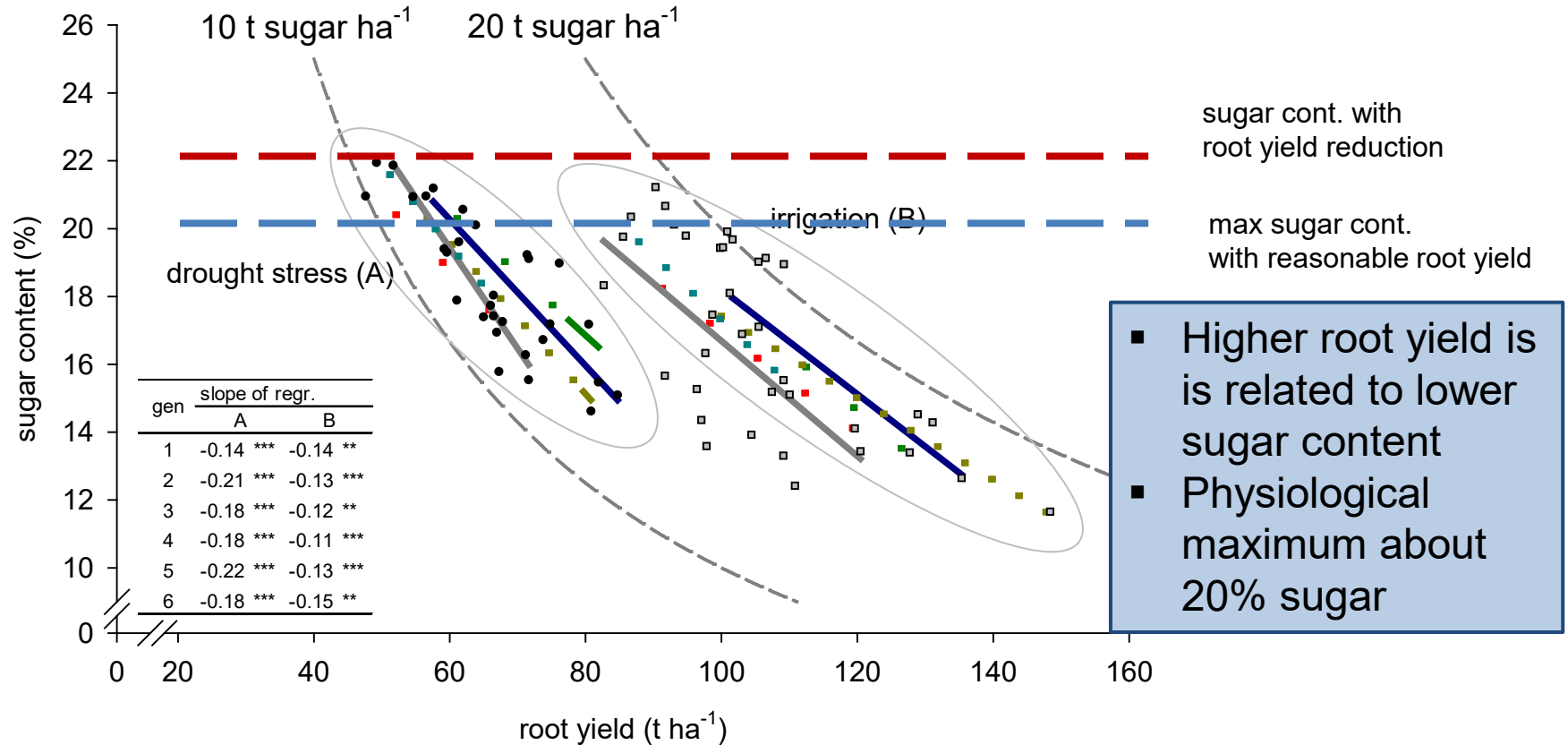
Sugar yield of genotypes in different environments
Field trials 2018 + 2019 with drought stress in Italy, France, Germany
(irrigated/non-irrigated = drought), Σ 8 environments, 4 genotypes
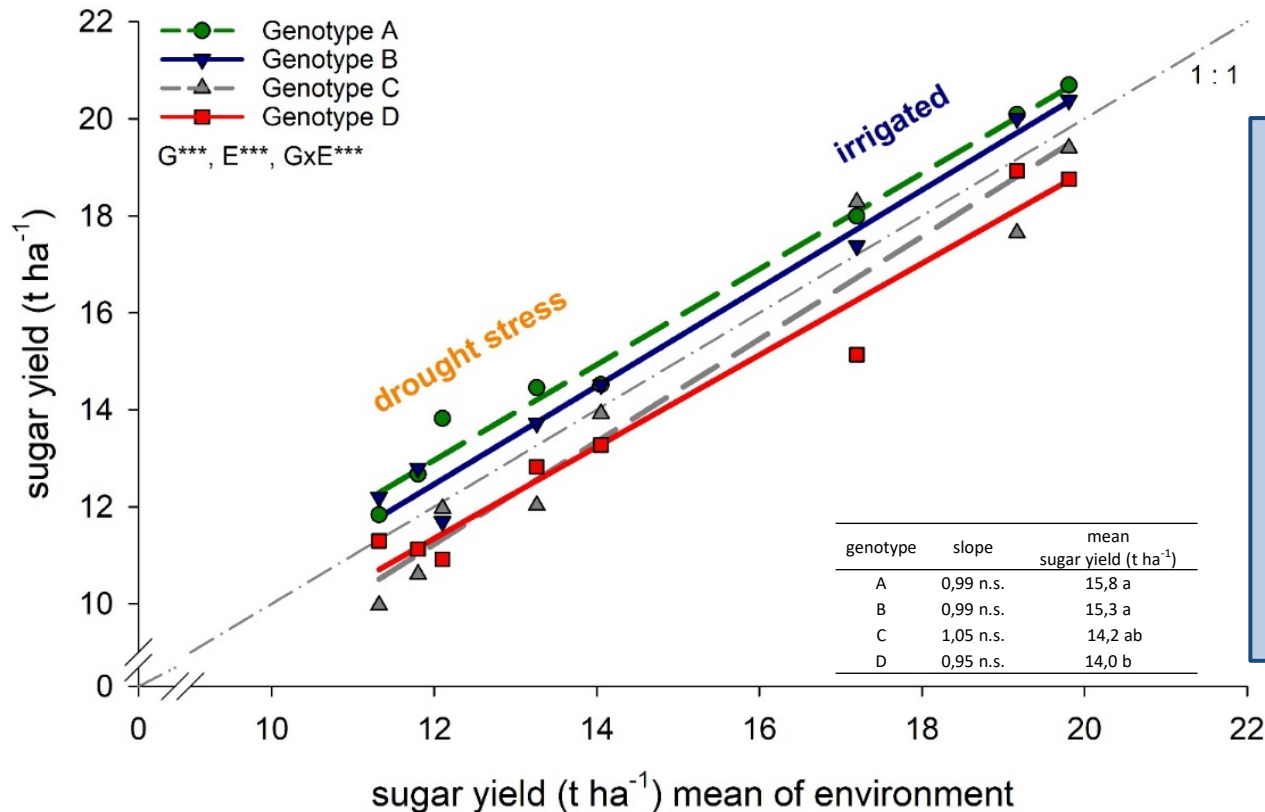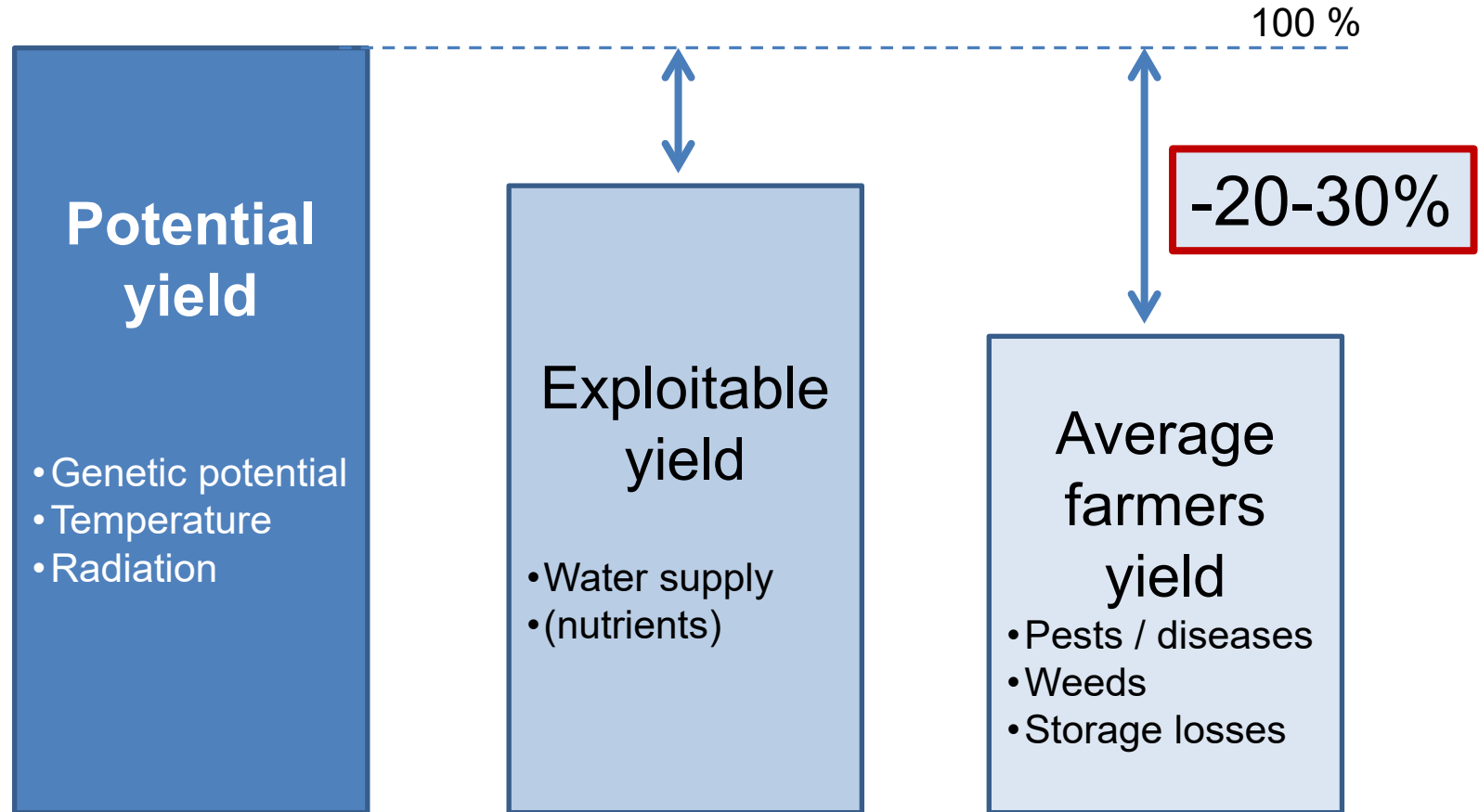

- Genotype ranking does not change
- Genotype performance not dependent on environment
- Not only high yield, but also high yield stability

Ebmeyer et al. 2021

Relationship between sugar content and root yield
field trials, 2018 + 2019 in Italy, France and Germany
(with and without irrigation=drought stress), 6 genotypes

gen	slope of regr.			
	A		B	
1	-0.14	***	-0.14	**
2	-0.21	***	-0.13	***
3	-0.18	***	-0.12	**
4	-0.18	***	-0.11	***
5	-0.22	***	-0.13	***
6	-0.18	***	-0.15	**

- Higher root yield is is related to lower sugar content
- Physiological maximum about 20% sugar

Potential yield and limitations

100 %

Potential yield

- Genetic potential
- Temperature
- Radiation

Exploitable yield

- Water supply
- (nutrients)

Average farmers yield

- Pests / diseases
- Weeds
- Storage losses

-20-30%

Perspectives and limitations
for the potential sugar production

➢ Variety development: high yields, shift in assimilate partitioning

➢ Extended vegetation period and early sowing:

   cold tolerance needed: early emergence and fast canopy closure

➢ High efficiency in water use: more sugar from the available water

➢ Focus also on yield stability, not only yield level

➢ Higher sugar content on the expense of lower root yield

➢ Take full advantage of the potential yield: management

Thank you for your attention!