Sugar beet (*Beta vulgaris* L.) yield and quality data at different harvest dates from a multi-environmental study in Germany

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Abstract: This paper presents data from a two-year study with sugar beet in Germany (2000 and 2001). A total of 27 field trials were conducted in a wide range of environmental conditions including trials with and without irrigation. Sequential harvests were made every 14-28 days between May and October. Root yield and quality, leaf yield, leaf area index and soil water content were determined in four replicates at each harvest date. Soil characteristics were assessed in the field and daily weather data were collected for each trial site. The dataset is suitable for validating sugar beet growth models.

Keywords: sugar beet, yield, yield formation, growth, roots, leaves, leaf area, root quality, weather conditions, available soil water, Germany.

1 BACKGROUND: The growth of agricultural crops is strongly influenced by site and year effects, particularly soil characteristics and weather conditions during the vegetation period. Insights into weather effects on crop growth are essential for optimising agronomic measures. Moreover, they have strongly gained in importance for estimating the effects of climate change on crop yields (e.g. Agnolucci et al. 2020; Anar et al. 2019). This dataset comprises yield and quality data of sugar beet from field trials and supporting soil and weather data. It was collected for a doctoral thesis describing the effects of weather conditions on yield formation of sugar beet (Kenter 2003). Another aspect of the study was root quality at different harvest dates, focussing on sugar content and various molassigenic substances which impair sugar recovery in the factory. The analysis of yield formation was published by Kenter et al. (2006) and the quality study by Kenter and Hoffmann (2006). Parts of the dataset were used for modelling studies by Qi et al. (2005), by Lenz (2007) and by Lenz-Wiedemann et al. (2016).

Additionally, the data were included in a review paper describing yield formation of sugar beet (Hoffmann et al. 2020). The present paper covers the complete two-year dataset and can be used for growth modelling of sugar beet. To our knowledge, a comparable dataset has not yet been published.

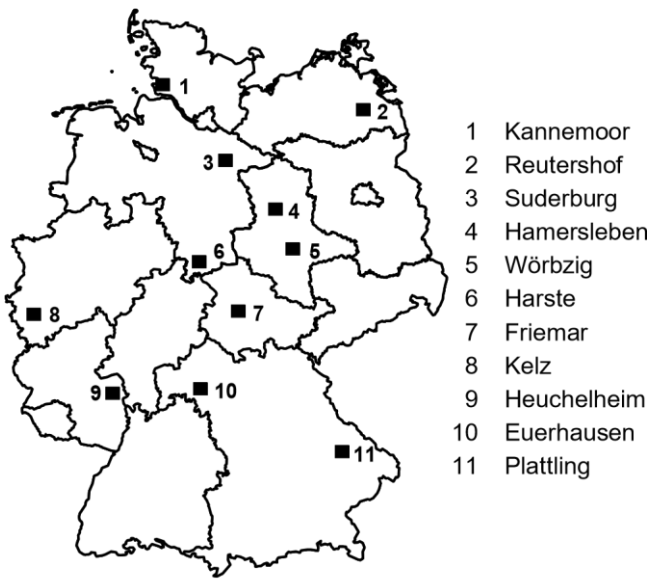

Figure 1. Trial sites

2 METHODS

2.1 Experimental design

The study was conducted in 2000 and 2001 on commercial farm fields in different beet growing regions in Germany (Figure 1).

Field trials with sugar beet were carried out on eleven fields in each year. They were set up after field emergence in a complete randomised block design with four replicates (10 m^2) for each harvest date. Only the trials at site 6, conducted by the Institute of Sugar Beet Research, were sown with a plot drill (10.8 m^2) and singled by hand.

Additional and identical trials on the same field were carried out with supplemental irrigation at sites 3 and 5 in both years and at site 9 in 2001. Crop husbandry was the farmers' responsibility. Soil texture

and soil type were assessed in the field (Ad-Hoc-Arbeitsgruppe Boden 1994). Plant available water in the effective root zone was calculated according to Müller (1997). Further details are given by Kenter (2003) and Kenter et al. (2006).

2.2 Sampling and analysis

Sequential samples were taken every 14 or 28 days between May and October to determine root and leaf fresh matter. The beets were topped and lifted manually and weighed after washing at the Institute of Sugar Beet Research. Leaves including tops were weighed in the field. Homogenised sub-samples of roots and leaves were dried at 105 °C to determine the dry matter content. Beet brei was prepared, quick-frozen (-70 °C) and stored at -20 °C. Soluble compounds were extracted with 0.3% aluminium sulphate solution. The filtrates were analysed for sugar, potassium, sodium and amino-nitrogen with an automatic beet laboratory system (Venema, Groningen, NL) according to ICUMSA (1994).
Subsequently, total soluble nitrogen was analysed in the filtrates by micro-Dumas combustion, nitrate using an ion-selective electrode, and betaine and reducing sugars (invert sugar: glucose + fructose) colourimetrically. Beet marc content (insoluble components) was determined according to Reinefeld and Schneider (1978). Further details on quality analyses are given by Kenter and Hoffmann (2006).
The leaf area index (LAI) was measured at each sampling date using the 2000 Plant Canopy Analyzer (LI-COR, Lincoln, NE, USA). Soil samples were taken from 0-30 cm, 30-60 cm, and 60-90 cm depth. Gravimetric water content was determined by drying by the samples at 105 °C and converted to plant available water content in each layer (Müller 1997).

2.3 Weather data

Daily values of air temperature (2 m above ground level), rainfall, solar radiation and humidity were recorded at the trial sites or obtained from nearby weather stations. As different weather parameters were available from various data sources, the potential grass evapotranspiration was calculated according to a German standard (Haude 1955). This simple approach, based on values of air temperature and humidity observed daily at 14:00 h, has proved appropriate in the modelling study by Qi et al. (2005).

3 DATA: All data are compiled in ten CSV files (Table 1).

Table 1. Data files and content

file name	content
1_sheets_variables.csv	description of data files, explanation of variables and units
2_site_information.csv	geographical position of the trial sites, long-term weather, soil properties
3_tillage.csv	tillage operations (covariates)
4_site_field_information.csv	irrigation yes/no (independently varied), annual pre-crops, soil mineral N, soil pH (covariates)
5_sowing_field_emergence.csv	sowing dates, sugar beet varieties and percent field emergence (covariates)
6_N_fertilisation.csv	N fertiliser and application rates (covariates)
7_irrigation.csv	dates of irrigation and amounts of water applied (independently varied)
8_field_data.csv	harvest dates (independently varied), soil water content (covariate), yield of roots and leaves, leaf area index, number of beets per plot, and sugar beet quality data in four replicates (response variables)
9_weather_data.csv	daily values of air temperature (mean and / or minimum and maximum), precipitation, global radiation, and potential grass evapotranspiration
10_weather_data_source.csv	data sources and locations of the weather stations

Data gaps occur for various reasons and are indicated by ‘NA’. In some cases, heavy rain during harvest prevented LAI measurements and / or leaf and soil sampling. Soil sampling was also occasionally

impossible due to severe drought, especially in 2001. Finally, some samples were lost during processing or laboratory analysis. Available soil water was not calculated for site 1 in either year due to the shallow groundwater at this site. Additional information on the trial fields and crop management was provided by the local farmers, but they did not always provide all the data requested. Gaps in the meteorological data are due to technical reasons.

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