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Systems for Yield Mapping Sugar Beets

Plot yield data, based on the weight of sugar beets delivered and subsequently after tare deduction, is reliable farm data. Satellite navigation technology made it possible to determine this farm data during harvest, site-specific with higher spatial resolution. While the area relationship is available with GPS, with sufficient quality and immediately, the throughput during beet harvesting can only approximately be ascertained. Contrary to site-specific online yield mapping in grain production, yield mapping in this field has not been introduced into practice till now.

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Keywords

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Literature

Literature references can be called up under LT 03221 via internet http://www.landwirtschaftsverlag.com/landtech/local/literatur.htm.

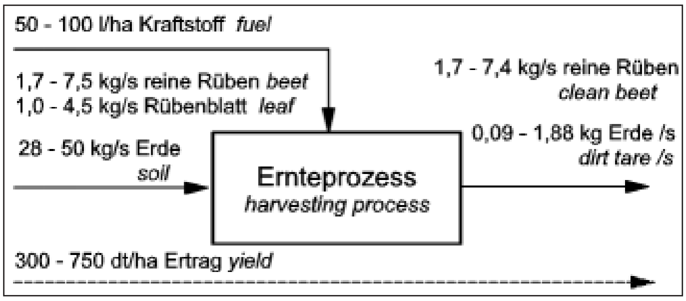

Fig. 1: Mass flow model for sugar beet harvest (for one row)

At present, sugar beet is cultivated on 450,000 ha in Germany with an average beet yield of 570 dt/ha. Cultivation sites are mostly characterised by homogeneous soil conditions and small structuring (with an average area cultivated of 9 ha)

Under these conditions, significant differences in yield seem unlikely. However, investigations of part-fields with yield sensoring systems [1, 2, 3, 4] have shown considerable variations in the distribution of yield within a field.

Real-time yield sensoring systems have to be employed in order to capture these site-specific variations in yield and to acquire information that can be applied in plant production. In this article, different approaches to the problem will be presented.

General framework

Concerning the general framework in which throughput can be measured, the following assumptions were made:
- The biotechnological framework is defined by yield ranges of:
  300 to 750 dt/ha clean beets
  1.4 to 3.5 kg/ m and row
- soil tare: 5 to 20 %
- lifting speed: 4.5 to 8 km/h

From these assumptions, the following values can be deduced for a mass stream model (*fig.1*)

Classification

Generally the yield can be determined either before, during, or after harvesting. Each of these procedures is characterised by specific advantages and disadvantages.

The easiest method, the empirical determination of yield, refers to single beets. One approach is to perform random sample lifting and to calculate from their results the yield data for the entire field. Alternatively, the average beet weight can be determined and multiplied with crop density to produce an estimate of the yield (Pesée geometric).

Both procedures are satisfactory for yield estimations. They do not, however, produce site-specific yield data, due especially to the high degree of variability in locational factors and to the limited scope of the random sample. Drawing exact yield maps requires an immense effort of time.

Yield measuring systems within beet lifters require determinating three values: crop yield, soil tare and position.

As long as there are no exact real-time measuring systems for determining the proportion of admixtures in the throughput, measuring should take place after the best possible separation of admixtures.

Measuring throughput on the basis of energy flow

Energy flow can be determined by measuring either fuel consumption or engine torque.

- measuring torque

Relatively little effort is needed to fit engines with torque meters. Adequate spots for such measuring are conveyors, turbines, or elevators. As soil tare is continuously separated from the beet during conveying to the hopper, it is advisable to measure torque at the end of the conveying chain.

- measuring fuel consumption

The difference in fuel consumption during no-load running and during material flow is decisive for the quality of the measured results. If the difference is small, variations in throughput cannot be measured with much exactitude, because influences such as uphill operation and variable soil conditions will make meaningful measurements improbable.

Measuring the throughput by determining the mass flow
Measurings of mass flow are classified as direct measurings.

• Weighing

Material flow weighing can be performed either continuously or at intervals on conveyors (including unloaders), on loaders, or on the entire machine (mW). Vertical movements of the lifter or its individual components will influence the measurements.

• Impulse measuring

Impulse can be measured at interfaces and impact points, and, combined with the velocity of the material flow, throughput can be determined on its basis. To avoid interference in the measuring, the stream of goods must be conveyed both to and from the sensor without obstruction.

Measuring throughput by determining the volume stream
The measuring of the volume stream is an indirect measuring procedure in which the mass stream is calculated by means of a multiplication with estimated or determined bulk density.

• profile measuring

The volume stream is determined on the basis of flow velocity. In order to ensure the exactness of profile measurements, it is advisable to install the corresponding measuring systems at points where the material flow is steady and smooth because bouncing beets impair the measuring process. Bulk density on the conveyor belt varies if the material flow is uneven. Moreover, an intrinsic problem of measuring procedures, relying on the volume stream, is the varying density of the material stream. Periodical calibrations improve reliability only slightly.

• Measuring the contents of the beet hopper

The continuous changes in the contents of the beet hopper are related directly to throughput. The determination of the degree of loading by means of sensors is difficult, either because of the large area on which the beets are dropped by the elevator, or because of an auger distributing the beets in the hopper. Additionally, the increase in volume (e.g., per second) is only marginal in relation to overall volume.

The systematic analysis of contemporary lifter-based technology for determining crop quantity has highlighted these problems:

1. The material stream in the lifter (mass or volume stream) always contains a mixture of beets and tops and soil tare. At present, it is impossible to determine exactly the proportions of these components. The variability of their composition results in errors concerning absolute mass and, therefore, in errors in the determination of site-specific differences in yield.
2. Measuring on the harvester is influenced considerably by exterior factors. For example, real-time measurements are distorted both by vibration of the harvester as well as sloping ground.
3. The measuring of the real beet yield depends on lifting and topping quality. Beet tops and severed root ends remain in the field and do not enter the crop calculations.

Yield can also be determined outside the lifter after the harvesting process.

1. Weighing of the loader in the field
2. Measuring of the clamp at the field's edge
3. Throughput measuring instruments on the cleaner-loader
4. Weighing of transport vehicles in the field or in the sugar factory

The weighing of transport vehicles yields the most accurate results. However, site-specificity, it can only be attained with high additional efforts because the weighing results must be related to the beets' original cultivation patch by hand.

The positive aspect of this procedure lies in the later correction of the initial measurements by subtracting the weight of soil and top admixtures. At present, weighing in the sugar factory is the standard procedure, and the amount of transported material thus determined can be used for the calibration and correction of site-specific online measuring procedures.

Combining yield estimation and online measuring

The discussion of advantages and disadvantages inherent in the different approaches suggests a yield measuring system installed in the lifter and drawing on individual beets (*fig. 2*).

Additionally, biotechnical data are collected, by means of which the masses of individual beets can be estimated. The addition of these individual beet masses and the integration of cultivation patches makes the site-specific measuring of beet yield in real time possible.

Beet counting

By means of counting, the number of beets is determined during lifting. Site-specific yield can be derived if the row distance is known, if the distance covered by the lifter is determined, and if the distribution of individual beet weight is assumed to be uniform. The individual beet weight on the basis of which this calculation is performed can be determined beforehand by means of random samples, or it can be corrected after delivery by the actual average beet weight.

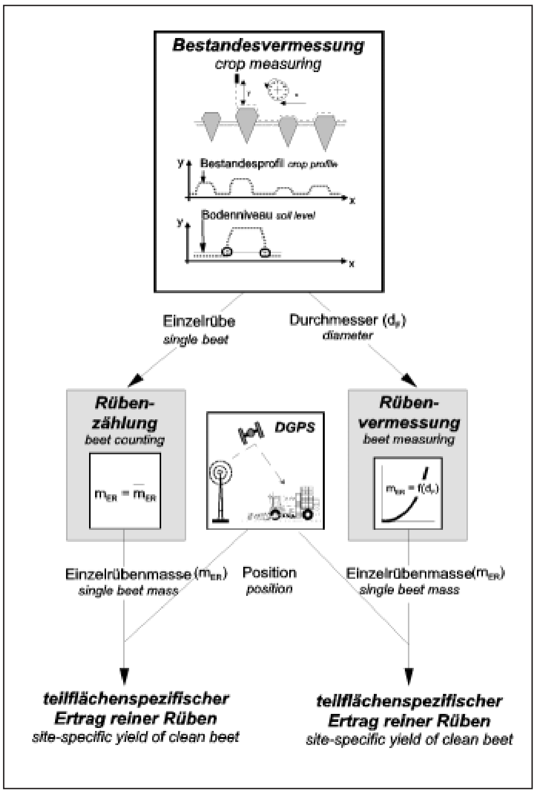

Fig. 2: Principle of counting beets and measuring beets

Beet measuring

The procedure of measuring individual beets is an improved development of beet counting. Instead of a multiplication of assumed average weights, this procedure adds the estimated weights of each individual beet. The estimates of individual beet weights are based on the maximum beet diameter.

Conclusion

There are various approaches to the site-specific determination of beet yield. The yield data, however, contain inaccuracies either because both beets and soil tare enter into the measurements or because values referring to clean beets contain inaccuracies in the estimated weight of the individual beet. The procedure, which is based on a count of the beets and an estimate of the weight of each individual beet, however, has an important advantage. Apart from determining site-specific differences in yield, it is able to provide information on yield structures (distribution of crop density, beet size, tip height).