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Area performance of silage harvesters

The basis of site-specific agriculture is the knowledge of yield potential in individual field areas. In forage production the problem of achieving a sufficiently accurate and functionally-secure real time area performance measurement has not yet been satisfactorily solved. Towards this goal, three different performance measurement systems were developed at the Institute for Agricultural Engineering, Bonn University and tested with wilted silage.

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Keywords

Site-specific agriculture, yield monitoring, forage harvester

Literature details are available from the publishers under LT 00326 or via Internet at http://www.landwirtschaftsverlag.com/landtech/local/fliteratur.htm.

The application of site-specific management in forage production can be defined as taking account of the different factors location, crop, inputs, technology and management with reference to yield, energy concentration and digestibility. For this, however, must be known the efficiency degree and effect of the individual factors for the field or the field-section. The site-specific parameters must be adjusted to the heterogeneity of the field. In an ideal case, such a spatial part can consist of a whole field with uniform soil fertility. The basis for an optimisation of productivity is the site-specific measuring of yield and the determination of relevant quality parameters.

A prerequisite for this form of precision agriculture is the measurability of the influencing factors and availability of cost-effective and reliable measuring systems.

One of the measurement tasks which, up until now, has not been satisfactorily solved is the yield real time measurement through the coupling of throughput and geo-reference data. The site specific yield is also the basis of a feed management system (quality, harvesting time, harvest, transport, conservation and feed supply).

Structural requirements

Harvesting forage maize with one to eight row, or row-independent, cutterheads, with increased row yields and differing maturity times gives, for working speeds of up to 8 km/h a specific throughput of up to 20t/h per row or a maximum 30 kg/s or 20 kg DM/s where crop moisture content is from 65 to 75%.

For wilted material the harvest throughput is from 9 to 18 freshcrop/s or 3.5 to 7 kg DM/s with crop moisture content from 40 to 70%.

Use of throughput measurement

The throughput of the silage harvester (in t/h or t DM/h) is a suitable parameter for:
• the area performance
• the energy requirement
• the performance requirement
• the wear
• the service intervals

Important use applications are:
1. The throughput is a suitable technical steering or regulating parameter for process-optimising of field operations (machine management systems; for instance the regulating of working speed), but also the optimising of parts of the procedure (post-chopping and determination of servicing intervals).

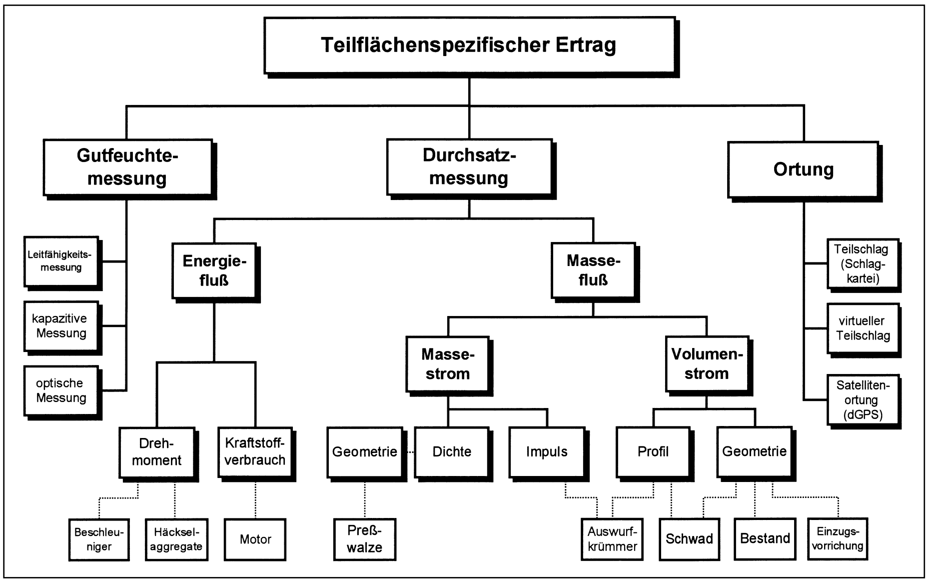

Fig. 1: Possibilities for ascertaining site specific yield with SP-forage harvesters

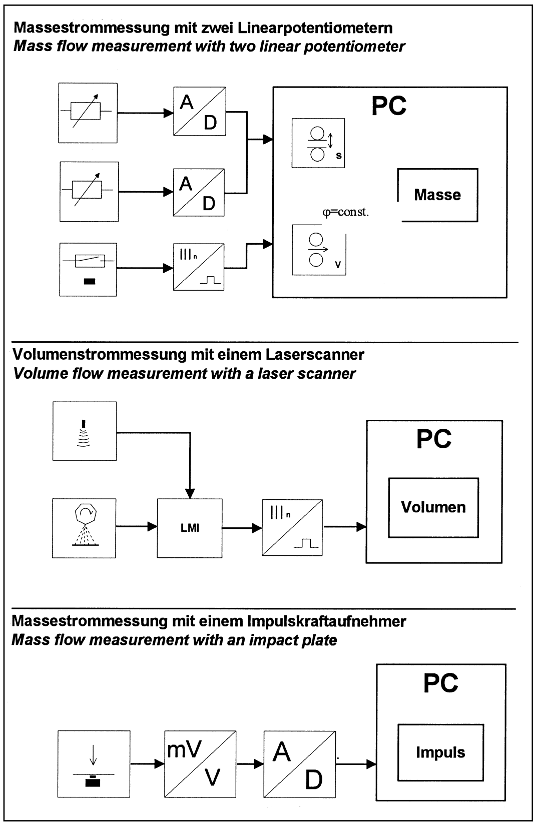

Fig. 2: Measuring systems of determining throughput

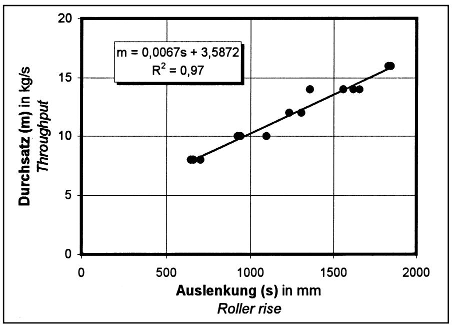

Fig. 3: Measuring mass flow at press rollers

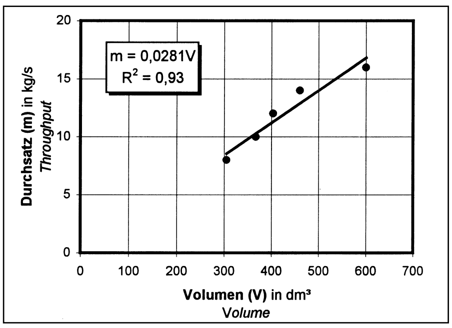

Fig. 4: Measuring volume flow with a laser-scanner

2. The calculation of the work progress according to the actual work done based on the harvested mass and the actual demand on the machines no longer takes place according to the harvested area only.
3. The throughput with information on position and crop moisture provides the site-specific DM yield the decisive parameter for describing location heterogeneity.

Technical solutions for throughput measurement

Systematised in *fig. 1* are the technical measurement possibilities for site-specific yield measurement. Hereby, the throughput – the amount harvested per unit of time in relation to the working width (number or rows and their spacing) and the working speed – is considered with reference to the harvested area.

Scientific investigations of throughput measurement are known from the literature even since the 60s [4,5] under altered technical prerequisites of [1,2,3,6,7].

The technical solutions for throughput measurement can be divided into:

- direct and indirect measurement
- wagon and silage harvester associated measurement

Direct measurement systems of cropflow are, in the case of silage harvesters without bunkers, only possible through the weighing of the transport vehicles – continually or at emptying – this means systems attached to the wagon or associated with measurement of cropflow, such as with the help of an impact plate. Ignored here for environmental reasons are measurement systems based on evaporation through short wave rays.

Indirect measurement systems based on connecting functions such as from the torque, performance requirement and throughput, or volumes of mass flow and throughput.

Measurement systems

1. Throughput measuring via displacement of press roller

For this, the volume flow speed over the press roller circumferencial speed determined, with consideration of the material/roller slip. The density of the material under the press roller has to be calibrated and is then available as a connecting function. For the geometrical measurement of the harvest material, a consistent division under the press roller is a prerequisite so that it is possible to measure the cross section from the breadth of the intake canal and the displacement of the press roller. The speed of the roller can be measured with a Reed-contact. The sensor frequency is 100 Hz. The precision B is 88 to 98% *(fig. 2)*. The advantage of this system lies in the limited individual cost of under DM 2000

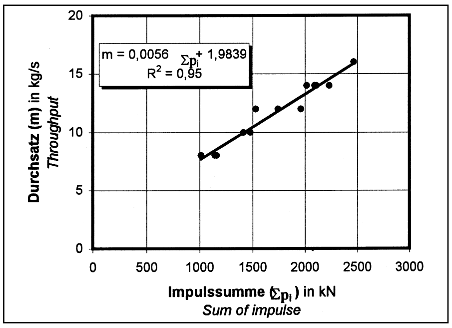

Fig. 5: Measuring mass flow with an impact plate

2. Volume flow measurement in the crop ejection deflector

Hereby is either the material flow cross section determined (ultrasonic) or the actual profile measured (laser scanner). A laser scanner is installed 700 mm below the crop ejection deflector and this records a 2-D profile. The amount of harvest material flow over a given distance is determined by a radar sensor (1 impulse per 8 mm). Volumes are thus calculated from the 2-D profile and the distance covered by the measured material. With a sensor frequency of 0.5 to 2 Hz, there results a solution of 10 dm^3. Problematical here is the empirical determination of the actual material flow density in the deflector. Despite this, a precision B of up to 93% can be achieved (fig. 4). Disadvantages of this system are the higher costs, which for this very elegant and reliable process top 20,000 DM.

3. Material flow measuring at the silage ejection deflector

This measuring system is based on the application of the impulse law. A commercial impulse power receiver is modified and installed at the end of the ejection deflector. The sensor frequency is 100 Hz. The precision B achieved with this system is 75 to 95% (fig. 5). This system can be problematical when the consistent impact of material against the impact plate is not secured. The costs of this system are expected to be under 10,000 DM in practice.