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Yield mapping on pasture – first results

A continuous crop throughput and yield recording system for a pulled disc mower with conditioner and swath layer based on belt-weigher technology was developed and tested. Used with a DGPS receiver the system delivered geo-referenced yield data. The standard deviations of the relative error regarding spatially specific recording compared on 12 m² reference parcels varied depending on field and yield level between 9% and 12%.

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Keywords

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Literature

Literature references are available under LT 02315e via Internet at http://www.landwirtschaftsverlag.com/landtech/local/fliteratur.htm

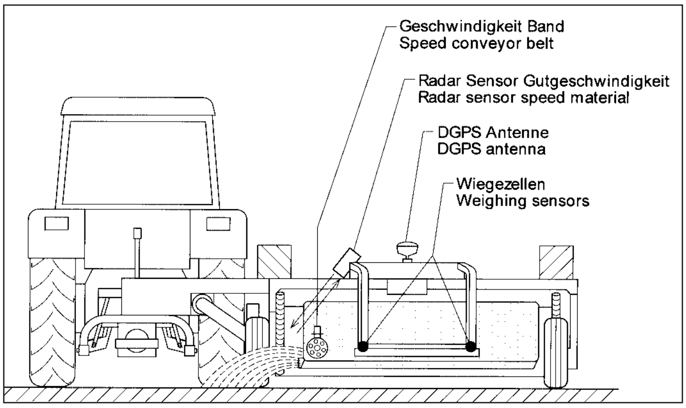

Fig. 1: Continuous yield measurement in a mower conditioner

Local yield recording represents an important starting point for spatially specific field management. So far, however, the system is limited to cereals and rowcrops. Because of this, an investigation within the framework of the Research Cooperation Agrarökosysteme München FAM was carried out with the aim of preparing geo-referenced yield data of green forage harvesting with disc mower. Developed and tested for precision was a yield mapping system for disc mower with conditioner and swath layer.

The challenge

Measurement systems of geo-referenced continuous throughput and yield have been developed for combine harvesters, self-propelled silage harvesters, sugar beet and potato harvesters and yield mapping for combines is by now offered by all manufacturers [2]. First measurement instrument for row-crop harvesters (potatoes and sugar beet) are also available on the market. The comprehensive development towards yield recording in silage harvesters has led to numerous publications [3, 5] and patent applications, although up until now no such system is commercially available. Yield mapping can be applied with a silage harvester for forage maize as well as grass although with the grass the measurement instruments tested so far have shown an increased error level [1]. Additionally, spatial-recording of yield presents a problem in grass because the crop material moved from growth point through turning and swathing and there is thus no fixed working width. Yield recording on the mower offered a way of solving this problem and also for assessing geo-referenced field data for hay. Up until now, however, no measurement system has been available for continuous throughput measurement in mowers. [4] investigated the possibility of the automatic and continuous recording of heterogeneity with a clover/grass stand via „pendulum meter“. The resultant relationships were very good. Verification, however, only took place during one cut on one location.

Material and methods

Within the framework of a cooperation project between the Specialist Dept. Technology in Plant Production and the Chair of Plant Nutrition TU Munich and Ingenieurbüro Rottmeier a mass-flow measurement system for a pulled disc mower and conditioner and swath layer (lateral conveyor belt) was developed, integrated into the mower and tested during three clover/grass cuts in 2001 on Testing Station Klostergut Scheyern. The development was part of a research project for investigating spatial heterogeneity of nitrogen fixing of clover/grass swards at the Chair for Plant Nutrition [6]. The 1365 pulled disc mower with conditioner and swath layer was supplied by John Deere. The measurement system was based on the belt weigher technique *(fig. 1)*.

The complete frame of the later conveyor belt was hung on the mower support arms via self-developed weighing cells capable of compensating for the horizontal forces produced by the material thrown backwards by the conditioner. The fresh weights recorded with 50 Hz were processed by a measurement amplifier. The slope influences – recorded by a twin-axis angle sensor – were also compensated for. The weight signal was processed together with the crop throughput speed as recorded by a radar sensor.

From throughput and area performance (working speed • working width) the area

Fieldname	Areas	Date	Parcel yield recording		Local yield recording in disc mower				
			Average yield	Parcel no.	Average yield	Number measure-ment value per parcel	Average erased parcels*	Average relative error	Standard dev. of relative error
	[ha]	2001	[t/ha]		[t/ha]			[%]	[%]
A03	1.5	24. 07.	17.26	99	18.24	75	21	1.31	12.63
A11	2.0	24. 07.	18.95	35	20.00	58	3	3.61	9.62
A12	3.4	23. 07.	20.47	128	20.88	68	17	-0.84	12.32
A09	2.5	02. 10.	11.39	92	12.15	57	26	1.96	13.63
A12	3.4	01. 10.	21.34	123	21.22	52	13	-2.13	11.24

*Recordings from parcels with >25% error were erased

Table 1: Accuracy of yield measurement in a mower conditioner 2001

yield was calculated and recorded with 1 or 5 Hz together with position information transmitted by DGPS receiver.

The recording over three cuts of clover/grass at the Test Station Klostergut Scheyern was done with the mower fitted always with active swath layer (lateral conveyor belt). As reference for investigating precision of yield data precise comparative weighings were carried out on three fields with 820 geo-referenced parcels each of 11.6 m^2 (2.9 • 4 m), the recorded results being compared with the average recorded yield values from the measurement equipment on the mower. This unusual procedure, in that it was very labour intensive, was justified in that, for plant nutrition calculations, the determination of dry matter content and sward composition of the parcels had to be tested for anyway. Additionally this procedure, only possible with the mower, offered the possibility of direct comparison between the „estimated“ yield on the basis of the yield recording system and „real“ yield from reference parcel harvests on the some location [7].

Results

After five different direct applications of extension measurement strips on the support arms of the lateral conveyor belt indicated influence load transfer onto the belt and horizontal forces, the specially prepared weighing cells between support arms and belt frame showed a very good performance. During the first cut, low frequency interference in the weight signal could not be filtered out. Altering the „give“ of the swath layer supporting shock absorber cured this disturbance. The system worked without interference in the second and third cuts. In total, yield recordings were carried out on 35 ha clover/grass.

Yield comparison between reference parcels and those recorded by the equipment on the mower (n = 50 to 80 measurement value/parcel) gave average errors on five separate fields between – 1 and + 3% *(table 1)*.

The standard deviations of the relative error in local yields from the 477 reference measurements varied, depending on field, between 9 and 12%. It was clear that the relative error reached its highest peaks where yield levels were low.

With this type of comparison the results needed to be discussed included precision of reference, error influences and precision of the yield recording system, all part of the yield measurement values.

Green crop yields of from 10 to 20 t compared with reference weights of from 12 to 25 kg per 12 m^2 parcel. Although the weighing cells used (hang weighers) had a resolution of 100 g (around 1% at 10t/ha) the error in the reference weighing of clover/grass in a 1• 1 • 1.5 m box can be up to 500 g (around 5% at 10t/ha) through possible wind influence alone. Regarding yield recording in the mower, influences on results along with the accuracy of the actual material weighing system must be added the determination of throughput speed, working width and working speed. The real accuracy of the weighing system could not be tested in isolation in 2001 but was to be clarified with further tests in the 2002 season. It has been shown that the recording of material throughput speed via radar sensor can be open to error when, because of low yields, the belt is poorly loaded and microwaves can permeate through to the belt surface. The extent of speed differences between individual layers of material on the belt at very high yield levels has yet to be clarified. The variation in the actual working width also had an influence on error, representing up to 10% on slopes. Measurements (n = 122) have shown that the mower (technical working width 3 m) worked during the trials with an average cut of 2.9 m (calculation factor for yield assessment). On steep side slopes there was, however, an uneven distribution with minimum working widths (with mower standing uphill from tractor) of 2.75 m (- 5.2%) and maximum working width of 2.94 m (+ 1.3%). The standing deviation in working width with low angles of side slope was 0.11 m (n = 51), by steeper angles 0.17 m (n = 71).

Summary and outlook

A continuously operating throughput and yield measurement system for a pulled disc mower with conditioner and swath layer on the basis of conveyor belt weigher technique was developed and tested. With a DGPS receiver the system delivered geo-referenced yield data. The standard deviations of the relative error of local yield determined by the measurement system compared with 12 m^2 reference parcels varied according to field and yield level from 9 to 12%. For determining basic accuracy of the throughput measurement, further trails were planned for the 2002 season where 50, 100 and 200 metre swaths from the mower are to be collected with the loader wagon, weighted as a whole and the result compared with the accumulated weight values from the yield recorder system (without working width and working speed error influences).

For determining the really interesting point of dry matter yield, moisture content information is necessary as with recording in combine or silage harvester. Worldwide research and development activities in the area of continuous measurement of higher material moisture (mostly per NIR) could in the future not only deliver necessary information of moisture content but also regarding material content.