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On-line comparison of yied measurement systems in combines

The yield measurement technique in combines has seen the modernisation of a decades-long tradition through spatially-specific management and GPS navigation. With this, demands for precision have grown, as has the importance of the influencing parameters. From two measurement techniques investigated one proved satisfactory, the other less so.

Measurement systems should be as accurate „as possible" with error as low as the expected difference between the variants. Spatially-specific management brings 1 to 3 dt/ha higher yield and leads to a variation of up to 5 dt/ha on the spatial areas. Thus, recording error should not exceed 5%.

The second requirement is associated with the reference area. Neither the field, the grain tank nor the trailer load counts for comparison. Instead, the amount from the spatial area is what counts. This area might be 30 m long but only as broad as the cutterbar, e.g. 6 m. With this, the spatial amount produces only 150 to 200 kg and this must be measured precisely. Errors have to be kept down with regard to the later mapping because the results from five combines will be assembled for one value.

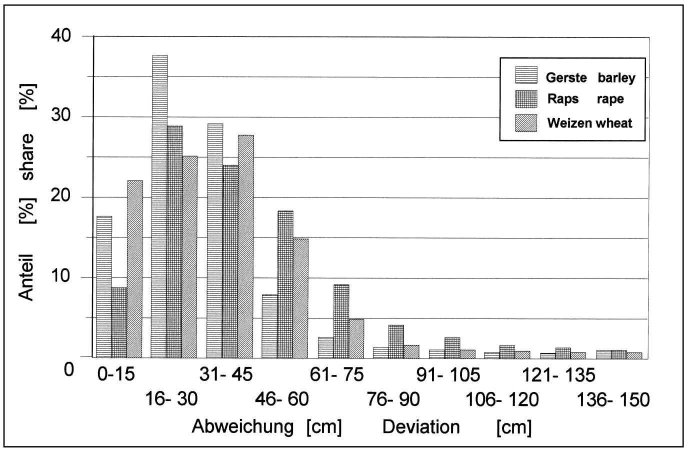

Fig.1: Distance between divider and crop (good driver for several flieds)

Factors for yield measurement

One may speak of yield measurement, but in reality the yield is calculated from measurable individual factors.

The recording of distance is relatively simple – through sensors on non-driven wheels, systems for which have proved themselves for years.

More difficult is getting the cutting with exactly right. Practical experience has shown that 30 to 40 cm, i.e. 5 % of the cutting width, remains unused. So long as this parameter remains constant it can be fed into the system. Own measurements indicate the extent of deviations from this value *(fig. 1)*.

Naturally, it would be more sensible to record precise cutting width through technical means. With this in mind, efforts have been made since the 70s to introduce an automatic steering system, with or without mechanical feelers. In the meantime, Claas has launched its „Laser Pilot" a system that automatically steers the combine along the standing crop edge and with this ensures continuous and full exploitation of the entire cutting width.

With respect to the short specific spatial areas, grain moisture in the grain flow must be continuously recorded because this can differ on a spatial basis by a few percentage points. This has some effect on the recorded yield but also gives information pertaining to soil and plants, e.g. to water availability.

Various measurement systems from different companies are available for recording grain throughput.

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Keywords

Cereal harvest, on-line yield measurement, measurement systems

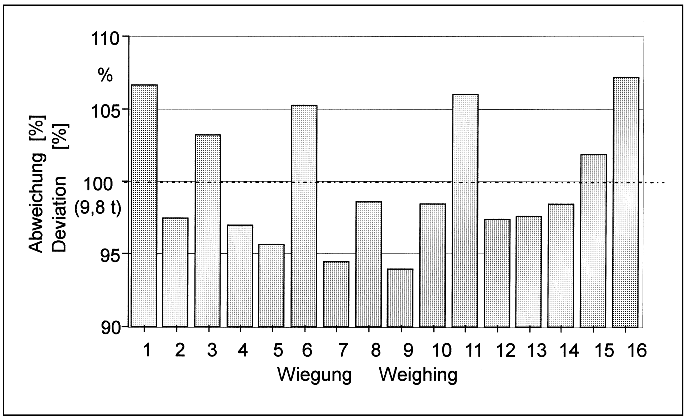

Fig. 2: Weight at the weigh-bridge (= 100) and measurement of the calibrated measuring system

The volumetric measuring principle records the height of the pile on the transport elements of the grain elevator via light beam. The volume, however, is dependent on many factors and has to be checked during the work.

The force-impulse measurement principle is based on the grain flow at a known elevator speed being measured by sensors as it hits an impact plate; individual model details differ between manufacturers. Under unsuitable conditions, green corn or rapeseed, which tends to be sticky, results in material adhering to the impact plate and this falsifies results. This system is calibrated through checking grain weight as it is unloaded from the tank. Calibration can also take place at the end of the harvest day.

Comparative measurement

Investigations from Weihenstephan offer information on the precision of measuring grain tank contents but not regarding the dynamic systems. Direct verification appears to be difficult. To help in this respect, both alternative systems were fitted into the same combine resulting in the influencing parameters throughput, cutting width, grain and threshing quality being the same.

Because both systems worked parallel to one another, they should also have the same throughput to record, although differing recording intervals have to be taken account of *(table 1)*.

Results

At first a few results from control weighings of grain tank contents were reproduced *(fig. 2)*. Average error was 2.4%, maximum 4%. Thus the deviation, as desired, lay below 5%. The range of the individual values meant that several control weighings were necessary for a calibration. The dynamic behaviour of both measurement systems was recorded on-line in the field. The yield was shown graphically over the length of the field strip, and exemplarily for the speed variants. Ideally, the curves of both systems should run parallel.

Where throughput is low (19 t/h) the volumetric system showed strong peaks up to 19t/ha *(fig. 3)*, i.e. for a low yield level the recordings were too high. These peaks appeared at short intervals and thus could not be explained by crop conditions.

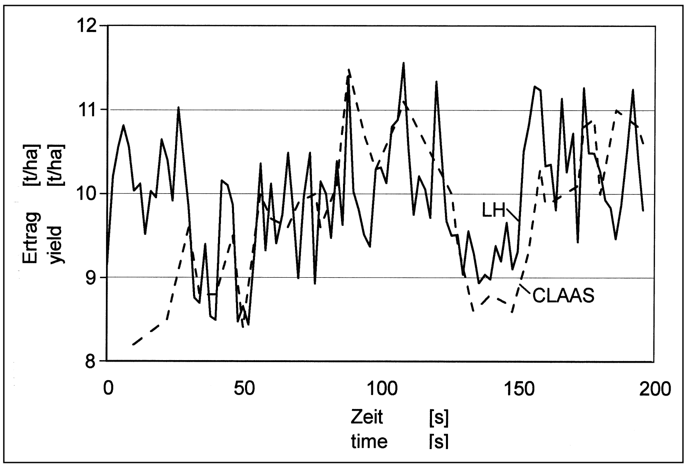

Fig. 4: Course of harvest-rate measurements of 2 sytems in a combine (4 km/h, Ø 24 t/h)

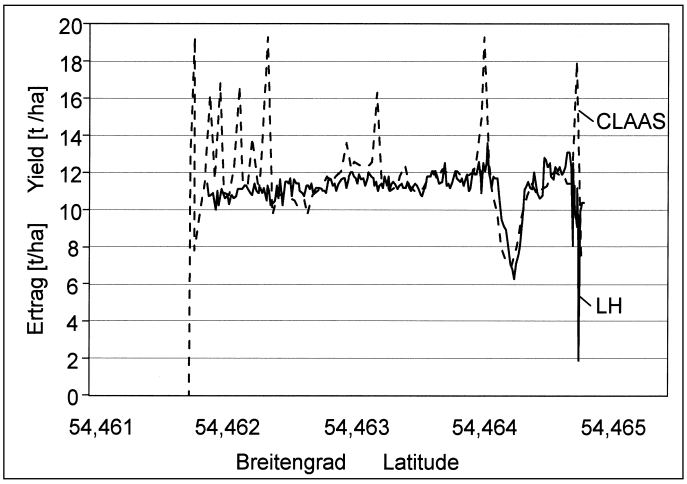

Fig.3 : Measurements at average harvest-rate (19t/h, 3 km/h)

Where throughput was lower (13 t/h), this behaviour was even more marked and, according to the manufacturer, was due to the following:

Because the elevator paddle was only transporting a limited amount of harvest material, there occurred a scattering of light inside the elevator housing. Where grain falls in front of an optical sensor it darkens the light source just as would a filled elevator paddle. Help here should come from a better sealing of the elevator housing and a more strongly concentrated light beam.

The effect of this fault can be negated through the right calculations when the clearly unrealistic value representing 15% is eliminated. Then, the two systems equal one another. Whereas the LH system was very consistent in recording 11 t/ha, the results from Claas sprung to 12 and 13 t/ha and finally showed a difference of 2 t/ha for the whole spatial area.

The high throughput of 24 t/h meant that the clearly faulty measurements were no longer a problem and instead the recordings were more like a practically explainable reality-near progression for both systems *(fig. 4)*. Both showed the same peaks. The differences between the systems were also shown in another example. The combine had to work through a lot of greencrop. This meant that the throughflow rose but not the weight.

The correlation calculation is in the first place made more difficult because of the different recording intervals. As compensation the recording intervals were made longer at 20 s. Then, the amount of increase of 1 neared $R^2 = 0.6$; but the amount of data fed-in dropped.

Summary

The LH system was shown as the more reliable. The values given by the Claas equipment improved with increasing throughput and approached that of the LH. However, for this a throughput of 20 t/h was required – a lot, even for big combines. Because average harvest was 20 to 25 t/h, often less. Alterations are planned.

The comparison of both systems was not based on a recognised reference system. In the context of this work it was impossible to realise the control weighings within the short recording periods. However, several aspects speak for the LH system: the vehicles with the grain tank contents showed less deviations in individual values than the volumetric system. In the on-line comparison, the LH system always delivered the curve progression nearest to the real situation.

		Interval	
		2s (LH)	5s (Claas)
Speed (km/h)	Average throughput (t/h)	Distance (m)	Distance (m)
2	13	1.1	2.77
3	19	1.66	4.16
4	24	2.22	5.55

Table 1: Different recording intervals (lengths covered) from two yield measurement systems with increasing speed and average throughput.