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YIELD MEASUREMENTS ON COMBINE HARVESTERS

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Summary:

In the harvest seasons 1991 and 1992 two yield measurement systems for combines were investigated on over 300 ha of small grain. Both systems, one basing on volume measurement, the other on measuring flow with a radiometric system, were investigated on reliability, measuring accuracy, range of measurement errors and reasons for measurement errors.

Keywords:

Combines, Grain, Yield, Site-specific,Measuring system

Yield Measurements on Combine Harvesters

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Abstract

In Germany, there are currently two measuring systems on the market that allow local measuring of yield. They are based, on the hand, on volume measurement and, on the other hand, on measuring flow on a radiometric basis. Both systems were tested simultaneously under practical conditions during the 1991 and 1992 harvests, using winter wheat and summer barley. In order to ensure accuracy, grain tank loads were weighed a second time on platform scales. The results obtained are the basis for evaluating the two measuring devices.

Introduction

In this day and age, local measuring of yield is becoming more and more important. Local information on yield potentials is made available this way, an important factor for contractor and machinery ring work. Additionally, taking into account previously supplied nutrients and uptake rates, the amount of nutrients remaining in the soil may be gauged more easily. This is important information for potential cost reduction measures. At the stage of fertilization, local yield measurement serves as a basis for the introduction of site specific farming methods, which ultimately result in a better protection of soil and environment.

Pre-requisite for this process are permanent, reliable yield measuring devices installed in the combine harvester. Several systems have been described in the literature. On the European market there are at the moment two systems ready for practical use. The YIELD-O-METER (CLAAS) works on a volume measurement principle (bucket wheel).

The device DATAVISION FLOWCONTROL (MASSEY FERGUSON) measures flow on the basis of a radiometric measurement principle. Each system, respectively, is installed at the upper end of the grain elevator in the combine harvester.

A two-year experiment was conducted in order to establish the practical usage potentials of these devices. The goal was to test reliability, measuring accuracy and a potential spread in the test data, and to determine reasons for measurement errors.

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Materials and Methods

Site of the experiment was the acreage of the research farm "Scheyern". After the research network "Forschungsverbund Agrarökosysteme München (FAM)" had taken over the farm, all arable land was cultivated in a two-year monitoring phase with one crop respectively, receiving the same treatment (Table 1).

Table 1: Acreage and Crops on the Research Farm "Scheyern" in 1991 and 1992.

	Year of Experiment	
	1990/91	1991/92
Total harvest area	120 ha	110 ha
Grain sowing date	11. - 19.10.1990	10.03. / 9. - 12.04.1992
Grain	winter wheat	summer barley
Variety	Orestis B5	Sissi
Fertilizing	160 kg/ha N	50 kg/ha N
Harvesting date	12. - 20.08.1991	03. - 07.08.1992

At harvest time two combine harvesters were employed simultaneously, yield measuring devices having previously been installed by the manufacturers. In addition, institute-owned technology for positioning and test data recording and processing was used (Tables 2 and 3).

The yield measuring devices were calibrated according to manufacturer's specifications. In general, this was repeated at the beginning of every working day and after each change of field. Moreover, starting with the 1992 harvest, the system of the combine harvester with the volume measuring device was newly calibrated each time after unloading. The intention was to analyze potential effects of calibration.

In order to avoid competition between the two drivers, the combines were employed simultaneously on separate fields, each harvesting the same fields every year. Every grain tank load was picked up individually and re-weighed on platform scales. Thus, it was also possible to determine moisture content and specific weight (density) of the grain at this point.

Results

Altogether, in the main experiment, 280 grain tank loads were harvested in two test years with two combine harvesters. In this period, no malfunctioning in the measuring devices could be detected. Extensive pre investigation runs also had proceeded without any problems.

The most important data with respect to the grain tank loads (specific weight, moisture content, relative variance between measuring device and platform scales) is depicted separately per harvesting day. (Figure 1-4).

Of the total of 274 available data records about the individual grain tank loads, 75 incomplete data records had to be excluded from further analysis due to omission of certain strips for investigation purposes.

Table 2: Operation Data of Combine I on the Experimental Farm "Scheyern".

Combine Harvester I	Year of Experiment 1990/91	1991/92
Manufacturer	CLAAS	CLASS
Combine typ	Dominator 108 Maxi (new machine)	Dominator 108 Maxi ('91 machine)
Yield measurement system	YIELD-O-METER (volume flow)	YIELD-O-METER (volume flow)
Cutting width / Engine power	5.10 m / 163 kW	5.10 m / 163 kW
Positioning	SEL GLOBOS LN 2000 (reversal DGPS, position corr.)	SEL GLOBOS LN 2000 (reversal DGPS, position corr.) + 2 x ASHTECH M XII (postprocessing DGPS, pseudo range correction)
Data aquisition system	CONTRON IP-Lite PC386 + SCHLUMBERGER Datalogger	CONTRON IP-Lite PC386 + SCHLUMBERGER Datalogger
Operation area	50 ha	40 ha
Number of grain tank fillings	72	39
Total yield	320 t	156 t
Number of operation days	7	4
Pre-investigation area	30 ha	15 ha

Table 3: Operation Data of the Combine II on the Experimental Farm "Scheyern".

Combine Harvester II	Year of Experiment 1990/91	1991/92
Manufacturer	MASSEY FERGUSON	MASSEY FERGUSON
Combine typ	MF 34 RS (new machine)	MF 40 RS (new machine)
Yield measurement system	FLOW CONTROL (mass flow)	FLOW CONTROL (mass flow)
Cutting width / Engine power	4.80 m / 162 kW	5.50 m / 195 kW
Positioning	SEL GLOBOS LN 2000 (reversal DGPS, position corr.)	ASHTECH M XII (base station) + TRIMBLE JUPITER / ASHTECH SENSOR (mobile stations) (online DGPS, pseudo range corr.)
Data aquisition system	CONTRON IP-Lite PC386 + SCHLUMBERGER Datalogger	CONTRON IP-Lite PC386 + SCHLUMBERGER Datalogger
Operation area	70 ha	70 ha
Number of grain tank fillings	109	60
Total yield	375 t	266 t
Number of operation days	8	4
Pre-investigation area	50 ha	10 ha

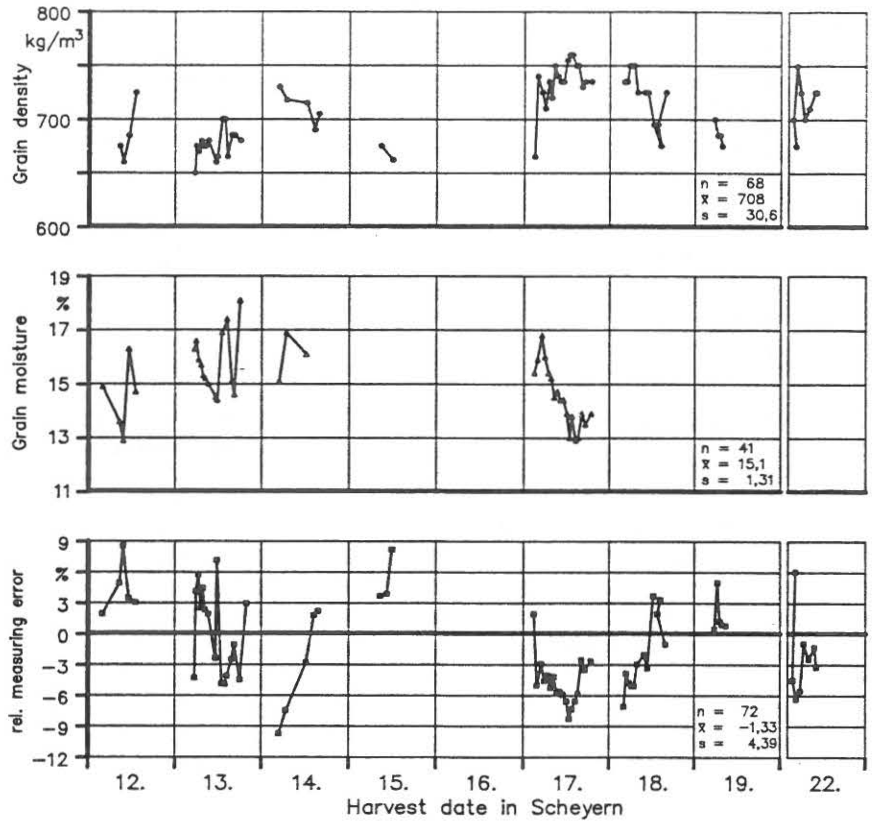

Figure 1:

Grain Density, Grain Moisture, absolute and relative Errors of each Grain Tank Filling for the Volume Flow System CLAAS YIELD-O-METER in 1991.

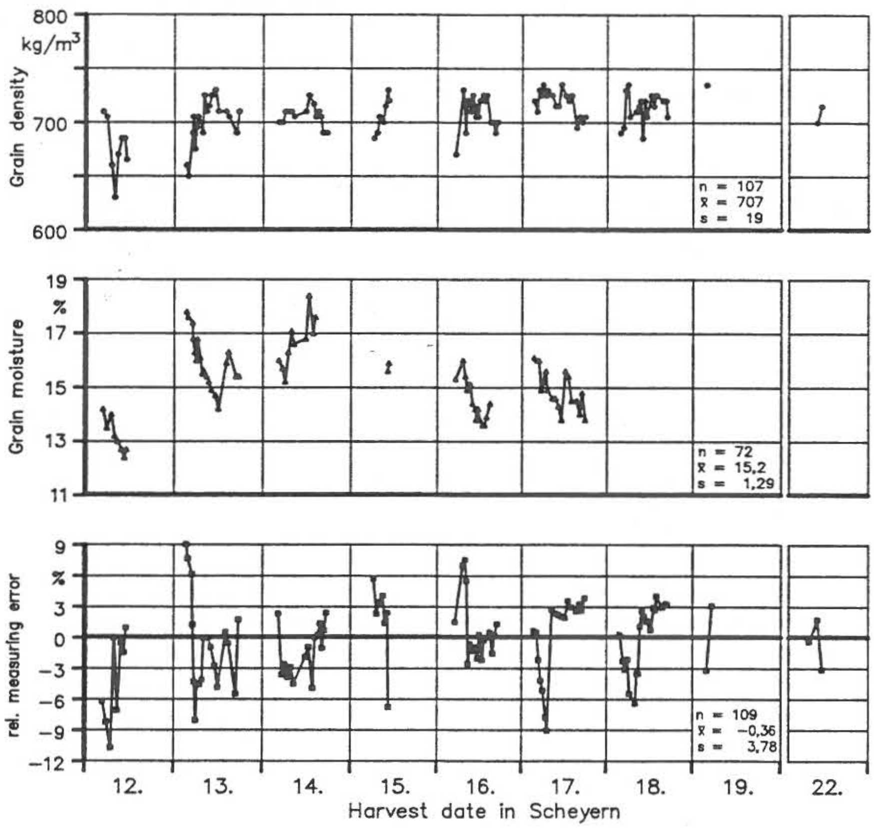

Figure 2:

Grain Density, Grain Moisture, absolute and relative Errors of each Grain Tank Filling for the Mass Flow System DATAVISION FLOWCONTROL in 1991.

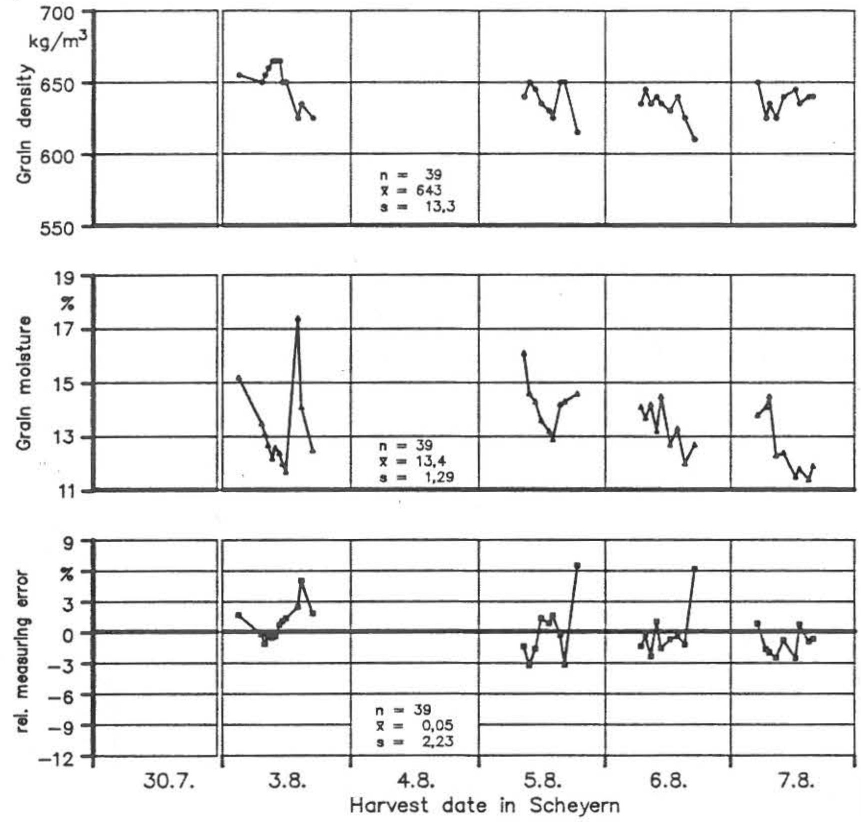

Figure 3:

Grain Density, Grain Moisture, absolute and relative Errors of each Grain Tank Filling for the Volume Flow System CLAAS YIELD-O-METER in 1992.

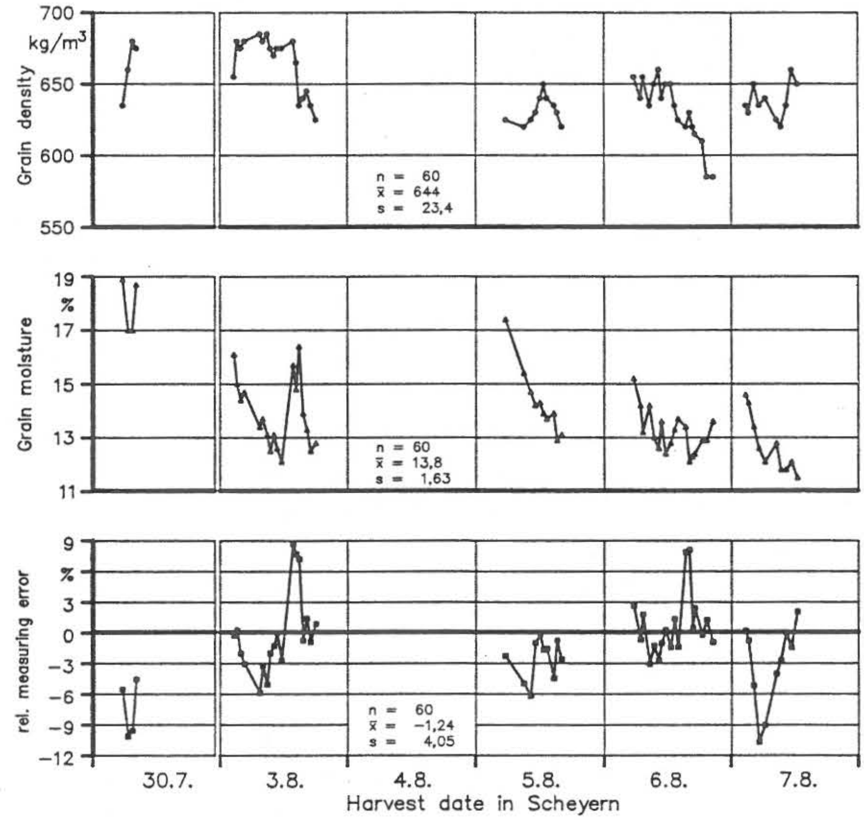

Figure 4:

Grain Density, Grain Moisture, absolute and relative Errors of each Grain Tank Filling for the Mass Flow System DATAVISION FLOWCONTROL in 1992.

Specific weight and moisture content correlate at 0.364 during the whole test period. This results in a coefficient of determination of 13.2%.

The relative variance between measuring device data and weight of the grain tank load as obtained at the platform scales ranged from +9 to -12%. The variance was greatest at the beginning or end of each working day. Sudden changes in the course of the day may be traced to field changes.

Using all 205 data records, the correlation of measuring accuracy may be determined by means of linear correlation and regression. For the volume measuring device YIELD-O-METER, an average variance of about -1% was established, with a standard variance of 3.77% (Figure 5).

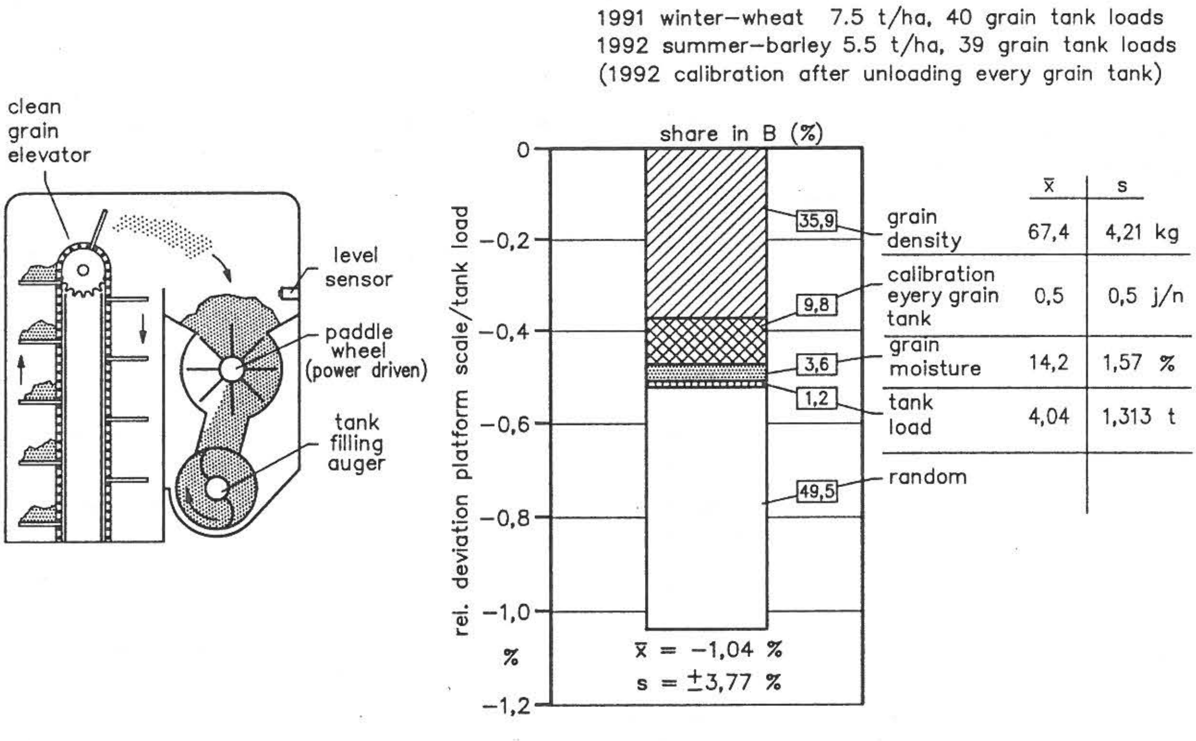

Figure 5: Relative Error of Volume Flow System CLAAS YIELD-O-METER.

The influence of specific weight on measuring accuracy per grain tank load with a coefficient of determination (r^2) of about 36% is highly significant. Furthermore, 10% (r^2) are due to the calibration of individual tanks and 5% (r^2) to moisture content and tank load. Together, all this accounts for more than 50% of the measuring error, indicating that this measuring system, albeit with a smaller accidental error, is highly dependent on the reliability of the personnel. (Calibration according to actual grain density).

The flow measuring device DATAVISION FLOWCONTROL on average shows an almost identical measuring error with a directly comparable standard variance (Figure 6). However, with this measuring principle, possible correlations remain very much in the background. More than 80% of the measuring error is random.

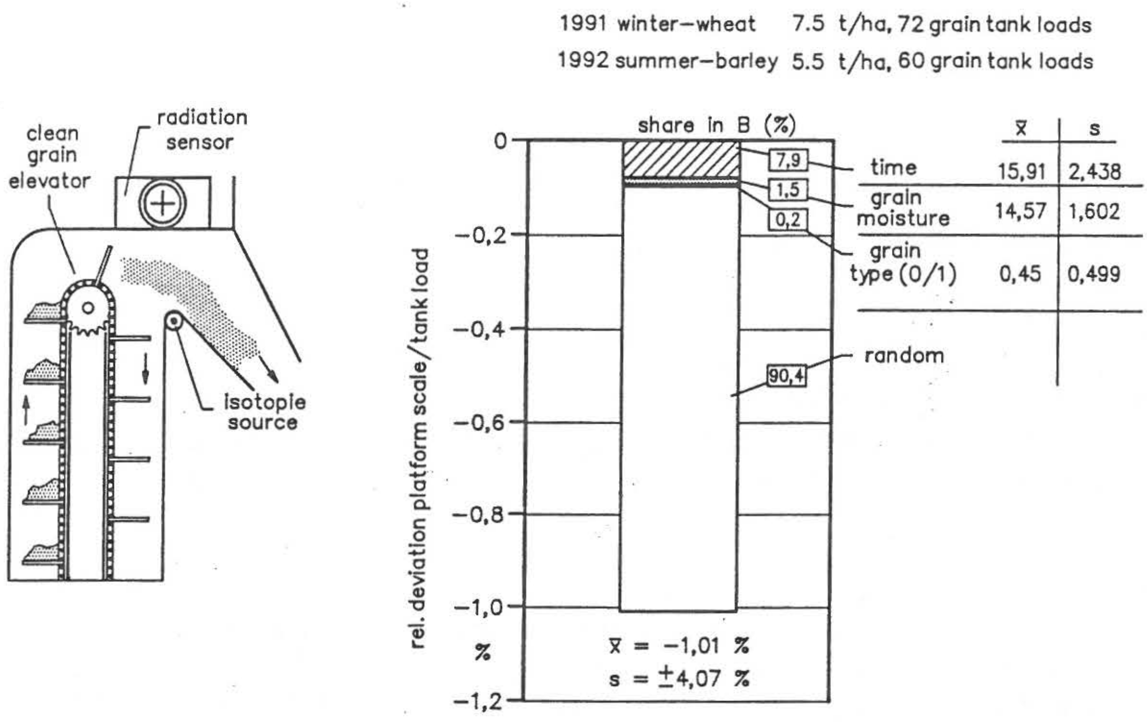

Figure 6: Relative Error of Mass Flow System DATAVISION FLOWCONTROL.

Conclusions

Based on extensive testing of both yield measuring systems under practical conditions, the following conclusions might be drawn:

- Functional reliability of the tested yield measuring devices is excellent. Malfunctions--if at all--might be expected with the mechanical volume measuring device at the harvest of a very moist crop.

- Measuring accuracy is almost identical for both systems and meets the general standards for local yield measurement. Actual differences in yield of about 10% may be determined this way.

- With the volume measuring system YIELD-O-METER accuracy is only guaranteed if staffers perform the necessary calibrations at the appropriate time. An automatic measuring of grain density seems to be unavoidable in this context.

- The flow measuring device DATAVISION FLOWCONTROL, on the other hand, is subject to special legal requirements (anti-radiation precautions) which differ from country to country. Radioactive contamination of the harvest due to this measuring system may be ruled out, however.

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