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Abstract and Summary

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Research to develop practical user guidelines to maximise the accuracy of moisture meters

by

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ABSTRACT

Accurate and reliable moisture measurement is essential for drying calculations, as well as for safe storage and marketing of grain and oilseeds. Most farmers rely on capacitance or resistance moisture meters for this task. These have limitations of accuracy: usually in the range ± 0.5%. This has implications for quality loss during storage as well as sale to end-users with added costs of rejections or claims.

The aim of this project was to assess problems that might occur under practical conditions and develop end-user recommendations to improve the accuracy of moisture measurement on farms. A review of factors most likely to cause variation in use was undertaken, in co-operation with meter manufacturers and selected farmers. This was followed by a survey of farmers and meter use on a number of farms to assess the variations under practical conditions.

Laboratory experiments were devised to compare readings from meters with the oven method (ISO 712:1998). No difference between the performance of capacitance and resistance meters was shown. Moisture content readings were repeatable for homogenous samples but readings from variable, but well-mixed, samples gave variable results even with the meter that used the largest sample.

The effect of variety on the results given by several different meters was assessed during both laboratory and field testing. A number of hard and soft endosperm varieties of wheat were compared in laboratory tests but no consistent effect on meter reading was found. No differences were detected in response of meters when testing different varieties of barley.

Resistance meters were inaccurate when the sample was under-compressed and the need for regular servicing of grinders was identified. Capacitance meters should only be used on a level surface.

Samples were taken from the output of a high temperature dryer. Readings taken using a capacitance meter were higher on average by 0.4% after six days when compared with readings taken immediately ex drier. No such difference was observed using a resistance meter.

An assessment of moisture probes showed their value in obtaining *in-situ* data from grain bulks. However, results were more variable than those of conventional meters and there was often a significant difference between moisture contents determined by probes and oven tests on samples removed close to the probe sensor.

On-farm assessments indicated that some farm meters gave markedly different results from manufacturer supplied test meters used in the work or oven tests. In several cases poorly maintained grinders were the source of error. Meters tended to under-read moisture at values above about 17%, often by more than 1%. This error was not seen during laboratory testing of samples.

A survey showed that most farmers had a realistic view of the accuracy of their meter, but were often more concerned with their meters agreeing with those of the merchant or end-user than with accuracy. This could have serious implications for quality and food safety, as accurate moisture content measurements are important when deciding on the need for drying to the correct moisture content and preventing ochratoxin A formation during storage.

SUMMARY

Measurement of moisture in cereals is of fundamental importance to safe storage and, ultimately, consumer safety. It also influences the value and saleability of a crop. The UK is often relatively damp at harvest time so that drying may be essential before grain can be stored safely, making moisture and its measurement of particular relevance in the UK. Farmers rely on electrical moisture meters to make these important measurements. Modern moisture meters measure an electrical effect in grain or oilseeds that is related to moisture content. They do not measure moisture directly and rely on an inbuilt calibration between moisture and the electrical parameter measured – usually capacitance or resistance.

There are many different models that adopt the two main approaches to measurement. This project did not attempt to assess individual meters, but used instruments from the main UK manufactures/suppliers that covered both principles of measurement.

The aim of this project was to assess problems that might occur under practical conditions and develop end-user recommendations to improve efficiency of moisture measurement on farms. It also addressed some specific issues that had been raised during HGCA Training Days and Road Shows or questions directed at HGCA researchers.

The first stage was completed with co-operation from meter manufacturers and selected farmers and provided an initial review of the factors most likely to cause variation in use. The factors identified were:

- Types of moisture measurement device (e.g. resistance, capacitance) and sample size
- Calibration issues
- Temperature effects
- Differences between varieties and crops (e.g. hard and soft wheat, oilseeds and cereals)
- Issues surrounding compressing or loading a sample

The International Organisation for Standardisation (ISO) routine reference method for the determination of moisture content for cereals and cereal products (ISO 712:1998) is the standard used for measuring moisture content. It was used throughout this

project to provide the ultimate assessment of the moisture content of all wheat and barley samples used for testing the meters.

A laboratory test was undertaken to test the variability of results obtained using the standard method employing the equipment used throughout this project. The moisture contents of 25 test portions taken from a single well-mixed sample of cereal were analysed. Tins containing test samples were spread over the top shelf of the oven to give the maximum variation of results. The maximum and minimum moisture content given by the test portions were 15.80 and 15.52 %.

Laboratory experiments were devised to estimate the scope of a number of problems, comparing meter readings with the ISO oven method. Five meters from four manufacturers were used in this part of the study. Two meters used resistance to determine moisture content and the other three meters used capacitance. One manufacturer of capacitance meters provided two different models and testing was done using one or other of these models and so laboratory tests were usually done using four meters from four manufactures.

The meters were operated in accordance with manufacturers' instructions.

Varieties of freshly harvested wheat and barley were collected from a number of sources to cover as wide a range of moisture content as possible. These were checked against at least one resistance and one capacitance meter in the field. The moistures were confirmed via oven tests and tested again in the laboratory using four meters. Where possible, the samples were tested using the farmer's meter.

The responses of the four meters were noted for three varieties of hard wheat (Welford, Brompton and Gladiator) and three varieties of soft wheat (Consort, Claire and Alchemy) at three levels of moisture content for each variety. Similar readings were also taken for three varieties of barley. Additional tests were done in both field and laboratory using a wider range of varieties of wheat and barley.

No difference between the performance of capacitance and resistance meters was shown and no difference between the response of the meters to hard and soft varieties of wheat or different varieties of barley was identified.

For all species and varieties, moisture content readings were repeatable for homogenous samples. However, readings from variable, but well mixed samples gave variable results even with the meter that used the largest sample. This was especially pronounced with freshly harvested grain.

A sample of wheat (Director) was dried in an oven for 3.5 hours at 45°C. Readings were taken using three of the four meters every hour for the first four hours after drying and then daily for four days. Readings taken in the first hour varied greatly, possibly due to the variation of moisture content within the sample. No consistent pattern of variation of moisture content readings over time from recently dried grain was found in this small-scale study.

Samples were collected on-farm during the high-temperature drying process. At each farm, samples were collected from the same batch before and after drying. These were tested immediately using a capacitance meter and a resistance meter. The samples were then taken for oven testing. The samples were tested again after at least 48 hours using both meters. No difference was seen between readings taken immediately and those taken after at least 48 hours using the resistance meter. However, when the capacitance meter was used, the readings taken after a delay were slightly higher than those taken straight away. This effect was most evident when the delay was six or more days, when the average increase in moisture content reading was 0.4 %.

Errors were introduced when the temperature of the sample and meter were not the same. Temperature differences of 9.9 to 14.4°C between meter and sample introduced errors of up to 0.7% moisture content. These results were confirmed during on-farm testing when some meters required time to equilibrate before they gave a reading and others gave a slightly different result after they had been allowed to equilibrate for one minute. Where there is a temperature difference between the meter and the sample, the moisture content should not be measured straight away. The sample should be left in a sealed sample bag or jar until the temperature of the meter and sample has equilibrated.

Errors of up to 0.5% moisture content were observed in the laboratory when the sample was under-compressed using resistance meters and a farm meter with a worn grinder gave errors of up to 1.2% of moisture content. This highlights the need for regular servicing of grinders.

Under-compression caused under-estimation of moisture content by an average of 0.4% in one resistance meter, where compression was delivered by a clamp. An error of 0.3% was introduced using this meter when the sample was ground too finely.

An error of 0.4% was introduced when a capacitance meter was used at an angle of 30°. This was due to the inbuilt balance not operating correctly when at an angle. Capacitance meters should only be used on a level surface.

The loading aids provided with 2 of the capacitance meters appeared to work effectively and no loading problems were noted.

Moisture probes are tools that were designed to support the management of bulk drying systems. They work on the same principles as conventional moisture meters and probably share the same software calibrations. However, they are considered to be inferior to conventional meters in respect of accuracy and consistency. An assessment of probes showed the value of these instruments in obtaining in-situ data from grain bulks. However, results were more variable than those of conventional meters and readings taken using probes varied from oven test results on samples removed close to the probe sensor by as much as 1.8% moisture content.

A survey of 158 farmers showed that most farmers had a realistic view of the accuracy of their meter of ± 0.5%, but 37% expressed a need for greater accuracy.

Although the overwhelming majority of farmers surveyed said that they have calibrations checked at least once a year, only 17% get their instruments checked by the manufacturer. The most popular methods of checking the calibration of moisture meters are to attend a clinic (49% of farmers) or to check against the meter of the end user of the product (27% of farmers).

Although not included in the questionnaire, many farmers commented that it was less important that their meter gave an accurate reading than that it agreed with the meter of the end user. This could have serious implications for quality and food safety as accurate moisture content measurements are important when deciding on the necessity of drying to the correct moisture content to prevent formation of ochratoxin A during storage.

Only 7% of farmers reported ever having had problems with their meters. Surprisingly, 65% of farmers had never had a moisture claim, but this could be explained by their adoption of a large safety margin (>0.5%) below the contractual value. Although 35% had suffered claims for high moisture content, most of these had known that they were near or above the maximum moisture level and so had been expecting a claim.