Measuring Corn Dry-Down: Validation of a Nondestructive Method

Javed, N.[1]*, Brar, N. K[1]. Reid, L. M[2] Lawley, Y. E[1].

[1] Department of Plant Science, University of Manitoba, 222 Agriculture Building, 66 Dafoe Road, Winnipeg, Manitoba, Canada R3T 2N2
2 Eastern Cereal and Oilseed Research Centre, Agriculture and Agri-Food Canada, Building 99, Central Experimental Farm, Ottawa, Ontario, Canada, K1A 0C6

Introduction

- Harvesting corn (*Zea mays*) at 25% moisture results in drying costs of about CAN$ 19 /tons—translating to 250.8 million for the 13.2 million tons of corn produced in Canada in 2016 (MAFRD 2017; Statistics Canada 2017).
- Farmers can benefit from the development of corn genotypes that dehydrate (drydown) faster at physiological maturity.
- Traditionally a destructive, oven based or gravimetric drying method was used to measure the moisture content of a corn ear or its components. This method is not efficient for a breeding program aiming to select for a higher rate of drydown in corn (Kang, Zuber, and Horrocks 1978; Reid et al. 2010).
- Reid et al. (2010) developed two calibration curves to estimate the corn ear or total corn ear moisture (TEM%) and kernel only moisture (KM%) by regressing gravimetric moisture measurements with the total corn ear reading (TEMR) from an Electrophysics MT808 meter, (Electrophysics, ON, Canada).

Objectives

- To validate the calibration curves reported by Reid et al. (2010) using an independent dataset created in this study.
- To assess the measurement differences between both methods (meter readings vs. gravimetric estimation)
- To identify the critical moisture concentration where the meter is capable of giving the most accurate measurements.
- To develop a global calibration curve by pooling both the datasets.

Material & Methods

- Samples for the calibration experiment were collected from a field study with a randomized complete block design and three replications.
- Plot size was 3.04 m x 8 m.
- Four corn hybrid treatments were seeded on two planting dates (May 20, and June 01) for a total of eight treatments.
- The field study was repeated in 2015 and 2016 and was located at the University of Manitoba Research Farm, near Carman, Manitoba.
- In each treatment, five corn ears were randomly selected on 26, 47 and 61days after silking and components of corn ear (husk, kernel and rachis/cob) were removed and processed separately for moisture measurements using both the Electrophysics MT808 meter (Figure 1A&B) and gravimetric method Figure 1B).

Statistical analysis:

- Linear regression with *NOINT*: Figure 2, 4, 10 & 11
- Slope comparison between the current study vs Reid et al. (2010): Figure 3 & 5 as described by UCLA: Statistical Consulting Group (2017).
- Altman and Bland (1983) plot analysis to assess agreement between both the methods: Figure 6 & 7
- Histogram: Figure 8 & 9 to check the distribution of measurement deviations of moisture content between the Electrophysics MT808 meter and gravimetric method.
- All statistical analysis were performed in SAS 9.4 (SAS Institute, Cary NC).

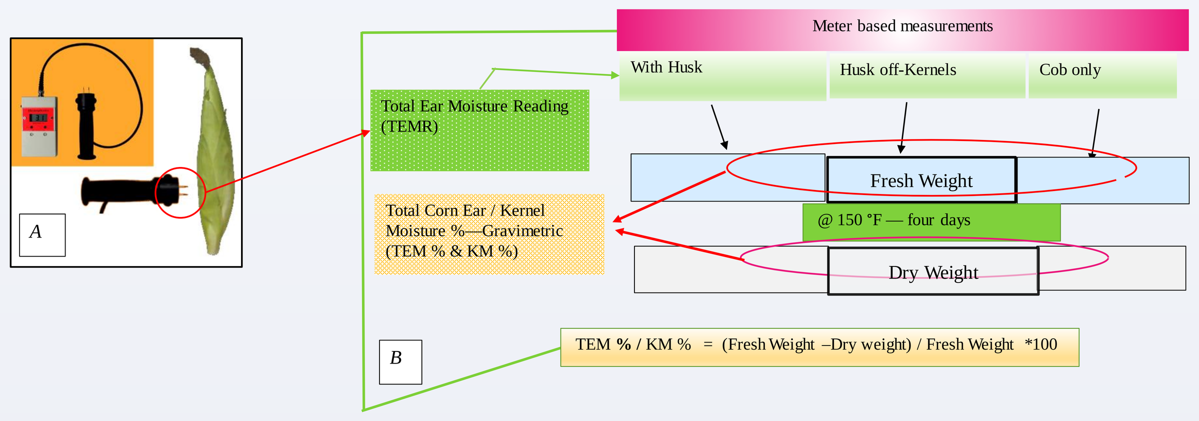

Figure 1 Electrophysic MT808 moisture meter (Figure 1A) and the process (B) followed to take moisture measurements using both methods (Meter and Gravimetric)

Results

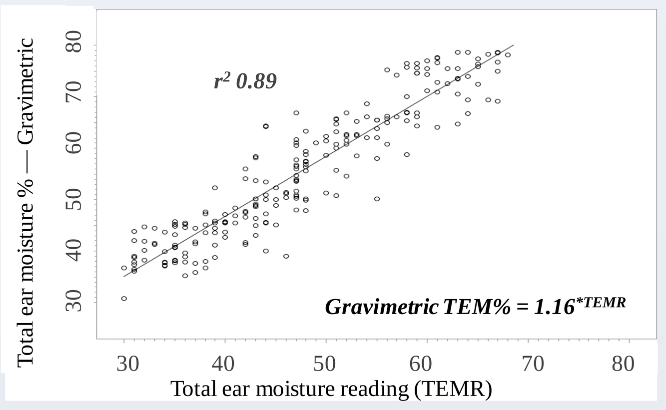

Figure 2 Relationship of gravimetric and total ear moisture reading during 2015-16

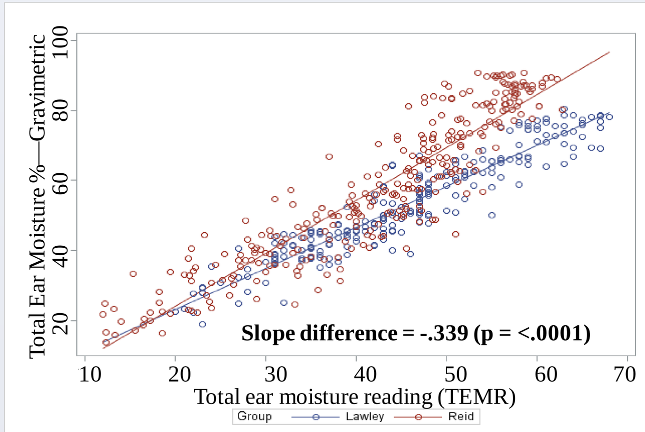

Figure 3 Slope comparison: the current study's (Lawley) with Reid et al. (2010) for total corn ear moisture

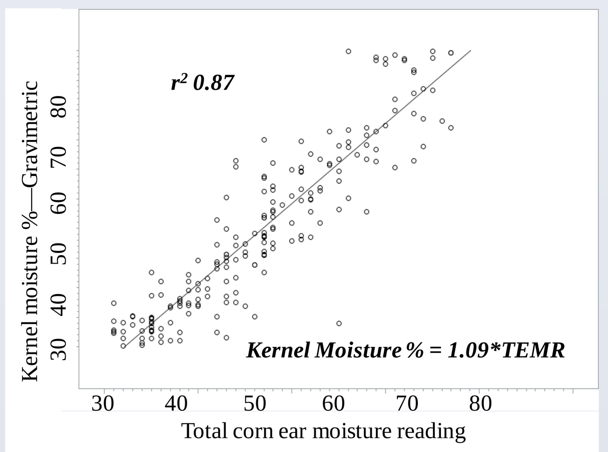

Figure 4 Relationship of kernel moisture % and total ear moisture reading during 2015-16

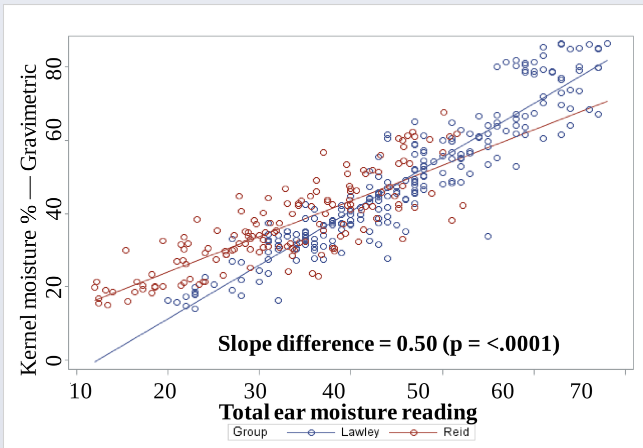

Figure 5 Slope comparison for kernel moisture content; the current study (Lawley) vs by Reid et al. (2010)

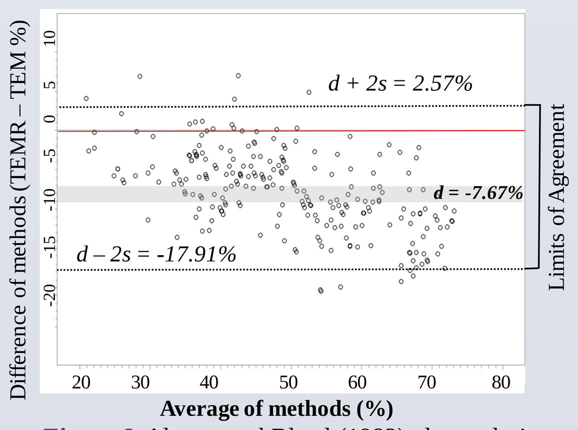

Figure 6 Altman and Bland (1983) plot analysis of the difference between the total ear moisture reading (TEMR) of the Electrophysics MT808 meter and gravimetric measurement of total ear moisture (TEM). Mean of method differences (d) ± 2S (Std. Dev.) sets the limits of agreement of methods in measurements.

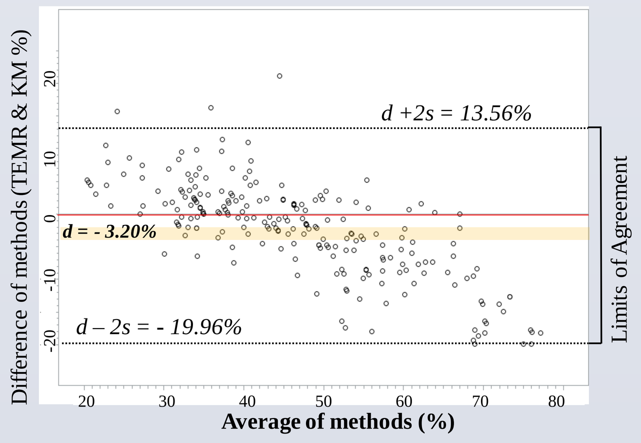

Figure 7 Altman and Bland (1983) plot analysis of the difference between the total ear moisture reading (TEMR) of the Electrophysics MT808 meter and gravimetric measurement of kernel moisture (KM). Mean of method differences (d) ± 2S (Std. Dev.) sets the limits of agreement of methods in measurements.

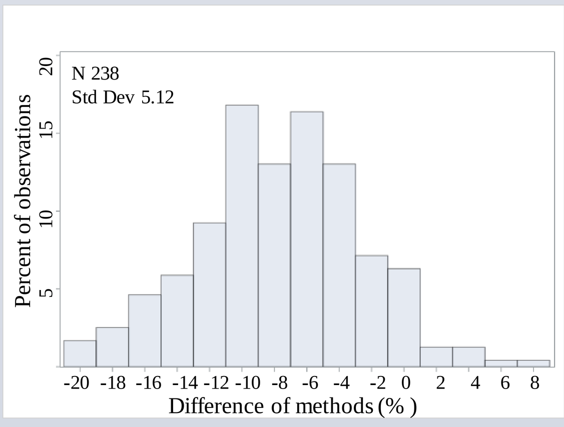

Figure 8 Frequency distribution of measurement differences of total ear moisture between the total ear moisture reading of the Electrophysics MT808 meter and the gravimetric method.

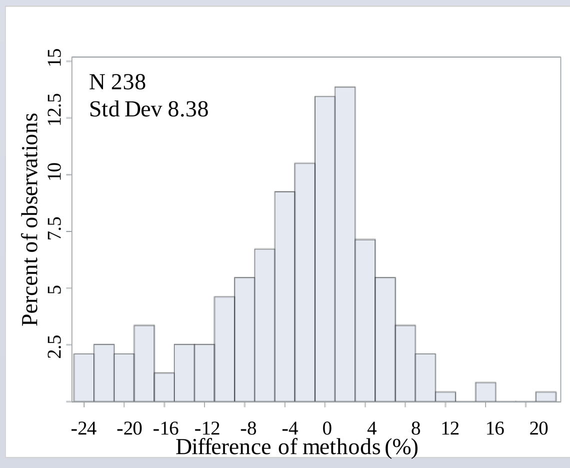

Figure 9 Frequency distribution of measurement differences for kernel moisture between the total ear moisture reading of the Electrophysics MT808 meter and the gravimetric method.

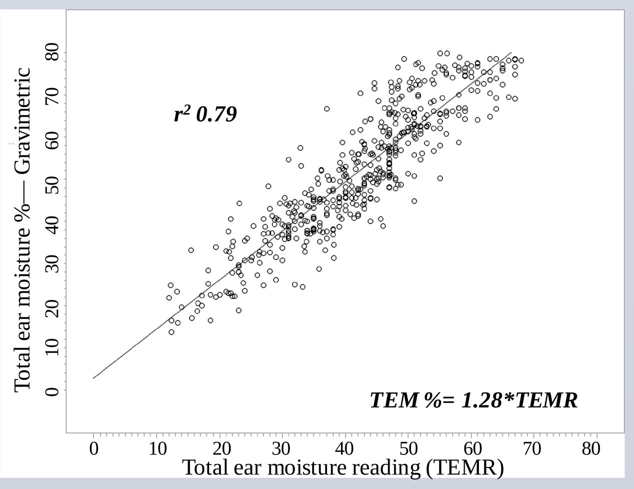

Figure 10 A global calibration curve based on the pooled data of current study and Reid et al. 2010 for the relationship between gravimetric total corn ear moisture (TEM) with the total ear moisture reading (TEMR) of the Electrophysics MT808 meter.

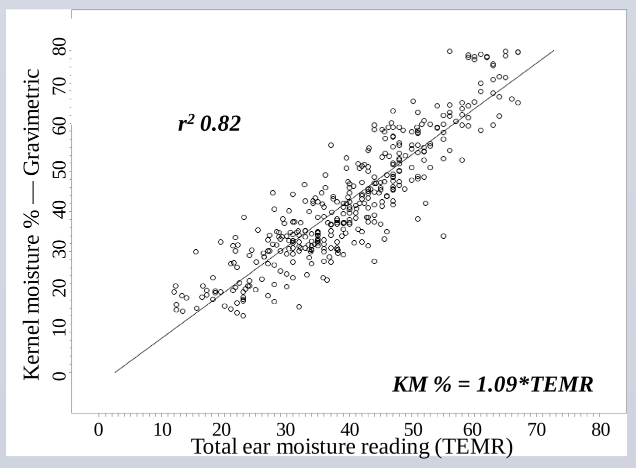

Figure 11 A global calibration curve based on the pooled data of the current study and Reid et al. 2010 for the relationship between gravimetric kernel moisture (KM) with the readings of Electrophysics MT808 meter.

Key Findings

- The Electrophysics MT808 moisture meter readings and gravimetric measurement of total ear and kernel moisture were highly correlated (r^2 0.89, 0.87 respectively in Figures 2 & 4). Therefore, this study confirms the findings of Reid et. al (2010) and that the Electrophysics MT808 moisture meter can be used as a rapid non-destructive tool to measure moisture content in corn.
- The Electrophysics MT808 meter most accurately measure the kernel moisture content of corn at 40-50% , when corn is typically in the dent stage. The meter underestimates the moisture content of both corn ears and kernels at gravimetric moisture contents higher than 50% (Figure 6 & 7). It overestimated the gravimetric moisture contents lower than 40%.
- The accuracy of the Electrophysics MT808 moisture meter is highest for kernel moisture content (mean bias -3.2 %, Figure 7) and lower for total corn ear moisture (mean bias -7.67 %, Figure 6). Similarly, 13% of kernel moisture meter measurements were identical to the gravimetric method, compared to 6 % for corn ear measurements (Figure 8 & 9). However, 54% of kernels moisture meter measurements were within ± 4 % of the gravimetric method (Figure 9).
- Pooling of original data from the current study and Reid et al. (2010) into a global calibration curve for the Electrophysics MT808 Total Ear Moisture Reading (TEMR) resulted in a revised equation for total ear moisture (TEM) = 1.28 x TEMR but the kernel moisture (KM) equation remains unchanged: KM= 1.09 x TEMR

References

Altman, D. G., & Bland, J. M. (1983). Measurement in Medicine - the Analysis of Method Comparison Studies. *Statistician*, *32*(3), 307-317. Doi 10.2307/2987937

Kang, M. S., Zuber, M. S., & Horrocks, R. D. (1978). Notes: An Electronic Probe for estimating ear moisture content of maize. *Crop Science*, *18*.

MAFRD. (2017). Guidelines for Estimating Grain Drying Cost (Calculator). Retrieved from http://www.gov.mb.ca/agriculture/business-and-economics/financial-management/pubs/calculator-graindryingcost.xls.

Reid, L. M., Zhu, X., Morrison, M. J., Woldemariam, T., Voloaca, C., Wu, J., & Xiang, K. (2010). A Non-Destructive Method for Measuring Maize Kernel Moisture in a Breeding Program. *Maydica*, *55*(2), 163-171.

Statistics Canada. (2017). Production of principal field crops, November 2016. Retrieved from http://www.statcan.gc.ca/daily-quotidien/161206/dq161206b-eng.htm

UCLA: Statistical Consulting Group. (2017). Introduction to SAS. Retrieved from https://stats.idre.ucla.edu/sas/faq/how-can-i-compare-regression-coefficients-between-two-groups/

Acknowledgements & Contact

Canadian Field Crop Research Alliance

Please, contact if you have questions or comments:
Nasir.Javed@umanitoba.ca