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ORIGINAL RESEARCH ARTICLE

COMPARATIVE EVALUATION OF NOVEL LOW-COST MOISTURE METERS SUITABLE FOR GRAIN MOISTURE MEASUREMENT

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ABSTRACT

Monitoring grain quality is an important postharvest activity which starts at harvest, continuing during storage and up to the point of sale. High moisture in stored maize can be detrimental to food safety because of the likelihood of aflatoxin contamination and other forms of deterioration. Moisture meters are devices which provide real-time access to measuring moisture levels thereby allowing farmers to meet grain quality requirements. A newly developed low-cost moisture meter known as the Post-Harvest Loss (PHL) moisture meter is a device with potentials for massive deployment among smallholder farmers. This study was therefore set up to compare the efficiencies of some existing moisture meters compared with this newly developed device. Two commercially available moisture meters — Dickey john GAC 2100 and John Deere meters were compared with the PHL moisture meter and oven-dried method (ASABE standards) used as control. Maize grains from a bagged storage experiment were used as samples over a 12-month period. Results showed that the moisture meters had a positive difference of <3% MCwb relative to oven-dried method. Average measurements showed variances of 2.34, 1.08 and 0.56% MCwb for John Deere, PHL and GAC 2100 meters respectively, when compared with the oven-dried method. Thus, it was concluded that the low cost PHL moisture meter may serve as an effective alternative to the more expensive types and may be relatively easy to adopt for laboratory and field use among smallholder farmers in sub-Saharan Africa.

1.0 Introduction

The quality of grain is influenced by its moisture content (MC) (Rai *et al.,* 2005). It is one of the important parameters considered when deciding price and quality at the stage of harvest, storage, processing and marketing. High moisture can lead to quality reduction and even crop loss during storage (Armitage *et al.,* 2008). When storage environments are not properly maintained, quality and economic losses can occur from such agents as mold growth and insect damage, which are usually the two most troublesome problems in modern grain storage

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structures. Appropriately low grain moisture contents and low grain temperatures are the primary weapons for preventing mold and insect infestations (Casada and Armstrong, 2008). There are two basic methods of determining the MC of biomaterials –the primary/direct and secondary/indirect methods (Obi *et al.,* 2016). A primary moisture measurement method involves determining the mass of an undried and dried sample to determine the amount of water in the sample (Armstrong *et al.,* 2017). In secondary methods, the MC is determined indirectly from the empirical relationship between physical and chemical features and the actual MC obtained from primary methods such as standard oven drying methods (Chen, 2003). Some common instruments used in secondary methods such as moisture meters and probes rely on the electrical characteristics of the grain, such as capacitance and conductance (Armstrong *et al.,* 2017) and are calibrated against the oven-based moisture determinations.

Heating whole grain in a hot air oven is the most widely used method for moisture content determination (ASAE, 2002), however the long drying time necessitated the development of moisture meters and probes. The need for a low-cost moisture meter in developing countries has been advocated for several years to help mitigate postharvest losses of grain (World Bank, 2011; Maier, 2015). Fast as well as field usable portable grain moisture meters and probes are a necessity to meet the requirements of farmers, grain storage personnel and agricultural products marketing corporations (Rai *et al.,* 2005).

Commercially available moisture meters include two low cost meters by developed country standards; the Post-Harvest Loss (PHL) meter which was developed under a USAID project to reduce post-harvest loss (~US$100) and John Deere portable device (~US$260, 2018 price). The GAC 2100 bench-top moisture meter is an approved moisture tester by the Grain Inspection, Packers and Stockyards Administration (GIPSA) and has been a highly regarded and used electronic meter (~US$3600, 2018 price).

The objective of this research was to demonstrate the accuracy of three moisture meters compared to the oven-dried reference method. The meters are — Post-Harvest Loss (PHL) meter developed by the USDA-ARS Center for Grain and Animal Health Research, Manhattan KS, John Deere Moisture Chek PLUS, model SW08120 (AgraTronix Streetsboro, Ohio) and Grain Analysis Computer GAC 2100 Agri (DICKEY-john Corp., Auburn, Ill.). Both laboratory and field tests of these four moisture measurements were carried out to validate their performance and to provide basic information on moisture levels of maize over a 12-month storage period.

2.0 Materials and methods

2.1 Maize

Maize used in this study was sourced from a single local farm in order to ensure uniformity of maize used for the study. Moisture content measurements of maize samples were collected during a study of insect infestation of bagged grains in a storehouse located in Arisekola market, Bodija, Ibadan (7°25′59 N, 3°54′43 E) from February 2017 – January 2018. Batches of 50 kg of maize were placed individually in bags according to the various treatments as follows: (1) untreated polypropylene (PP) bags,(2) Insecto diatomaceous earth–treated PP bags, (3) PICS bags, (4) PP bags with a single hermetic liner, (5) ZeroFly storage bags, (6) Insecto diatomaceous earth-treated ZeroFly storage bags, (7) ZeroFly storage bags with two PICS bag hermetic inner liners and (8) ZeroFly storage bags with a single hermetic liner. Each bag had three sub-replicates and were measured for each treatment. Monthly moisture measurements were taken for non-hermetic treatments while moisture measurements were taken every four months for the hermetic treatments.

2.2 Moisture content measurement and data collection

2.2.1 Post-Harvest Loss (PHL) meter

The PHL meter was used by inserting the probe deep into each storage bag of maize in the storehouse, left initially to stabilize over a 6-minutes period and then the temperature (°C) and relative humidity (%) of air surrounding the grain determined was used to calculate and display the moisture content of the grain. Three measurements were taken from each bag — at the center, and opposite sides of the bag and the average moisture content, weight basis (MCwb) calculated for each bag. This procedure was performed in the storehouse.

Inaddition to the field moisture data, a 1.2m open-ended grain probe (Seedburo Equipment, Chicago, IL) was used to sample maize from bags. Composite samples were taken from the center and opposite sides near the inner surface of each bag and placed inside labelled Ziploc bags. Samples collected were then transported to the laboratory for data collection. About 700 g samples collected from each bag were mixed thoroughly in a tray to ensure homogeneity for moisture readings with GAC 2100, John Deere moisture meters and Oven-dried method.

2.2.2 GAC 2100 moisture meter

Maize sample was poured into the top unit of the moisture meter; the load key was depressed and the sample automatically loads the grain into the test cell and a strike-off arm levels and removes the excess. After about 15 seconds, the moisture reading and grain temperature was displayed on its LCD. Three sample measurements were taken and the average MCwb was calculated for each bag. Moisture reading for the first month (February 2017) was however not available at the beginning of the study.

2.2.3 John Deere moisture meter

Sampled grain was scooped with a hollow plastic spoon into the top chamber of the meter and the cap screwed on to compress the grains around the electrodes. A uniform pressure was maintained on the test sample by a plunger in the cap which contains a heavy spring, allowing the plunger shaft to protrude through the cap as pressure on the grain increases. The plunger shaft was set flush with the surface of the cap each time a sample was tested. The unit was powered by two 9V batteries to run the backlight display and the microprocessor which then reports the water content and temperature of grains digitally. Three sample measurements were taken and the average MCwb was calculated for each bag.

2.2.4 Oven–dried method

100 g samples (replicated two times) were oven-dried at 103°C for 72 hours (ASABE, 2008) using a Memmert UF 55 Model 30-750 oven (Memmert GmbH + Co. KG, Schwabach). After heating, the samples were allowed to cool inside a dessicator and the MCwb was calculated for each bag. Two sample measurements were recorded and the average MC was calculated for each bag.

2.3 Statistical analysis

Data were summarized using the SPSS version 20 software to evaluate means of each response variables.

3.0 Results and Discussion

3.1 Grain moisture content

In the non-hermetic bags where monthly moisture measurements were taken, moisture levels recorded by the four methods in the bagged maize were higher at the end of the study compared with moisture levels at the beginning (Fig. 1). In the hermetic bags, slight increases in moisture readings were observed in months when measurements were taken (Fig. 2). MCwb readings using the oven-dried method were uniformly lower than all the 3 moisture meters used (Figs. 1 and 2). Among the moisture meters, GAC 2100 meter readings were consistently lower than the PHL and John Deere meters. There were variations in the monthly measurements of moisture in the triplicate bags during storage period. Moisture readings progressively increased during the rainy season (April to October) but fell during the dry season (November to January). High humidity observed during the rainy season which allows moisture gain from the surrounding air and low humidity during the dry season accounted for the initial gain and later, loss of moisture from the grains during the study. This appears to show that bagged grains respond readily to monthly variation in climatic conditions (Armstrong *et al*., 2017). Combined moisture measurement for all bags (hermetic and non-hermetic) showed that the John Deere, PHL and GAC meter readings had mean positive differences of 2.34 ± 0.34%, 1.64 ± 0.27% and 1.08 ± 0.31% MCwb respectively, relative to the oven-dried method. Comparing the moisture meters, John Deere meter had a mean positive variance of 1.26 ± 0.38% MCwb relative to GAC 2100 and PHL meter had a mean positive variance of 0.56 ± 0.25% MCwb. This result was in agreement with Armstrong et al., 2017 who showed that PHL meter readings were lower than John Deere moisture meter stating average positive differences of 0.45% and 2.12% MCwb for PHL and John Deere meters respectively, relative to the GAC 2100 meter. Overall, moisture levels in the bagged maize over the 12–month storage period were within safe levels for maize storage; an average of 12.82% MCwb was recorded in all the bags. The highest moisture level recorded for any bag was 15.5% using John Deere meter.

4.0 Conclusion

The use of robust moisture meters is important for farmers and grain managers to constantly monitor moisture levels of stock. The PHL meter, John Deere meter and GAC 2100 meter provide simple and rapid prediction of moisture readings of stored grains in the field and laboratory, thus enabling farmers to make quick decisions on the maintenance of quality of their grains.

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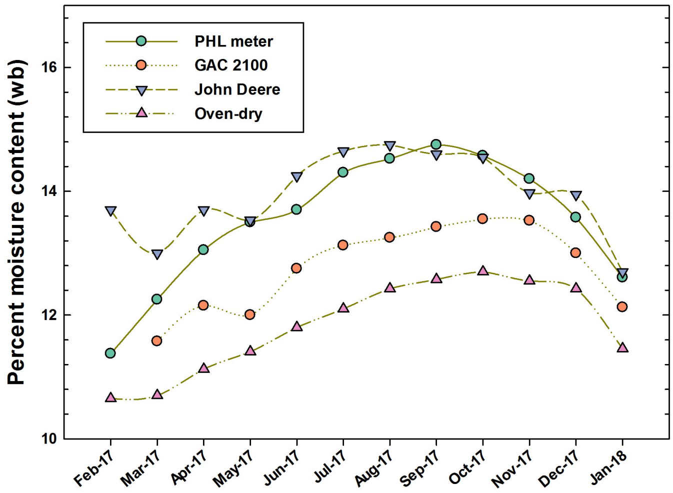

Fig 1: Monthly moisture measurement in the non-hermetic bagged maize from February 2017 to January 2018.

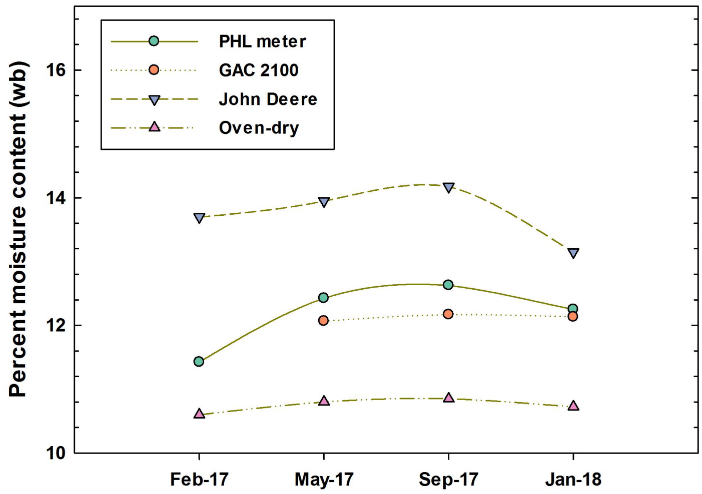

Fig 2: Quarterly moisture measurement in the hermetic bagged maize from February 2017 to January 2018.

References

Armitage, D., Wontner-Smith, T. and Wilkin, R. 2008. Grain moisture – guidelines for measurement. HGCA publication. Caledonia House, London. www.hcga.com.

Armstrong, PR., McNeil, SG., Manu, N., Bosomtwe, A., Danso, JK., Osekre, E. and Opit, G. 2017. Development and evaluation of a low-cost probe-type instrument to measure the equilibrium moisture content of grain. *Applied Engineering in Agriculture*, Vol. 33(5): 619-627 https://doi.org/10.13031/aea.12266

ASABE Standards. 2008. Moisture measurement – Unground grain and seed. Standard engineering practices data. *American Society of Agricultural and Biological Engineering*, 56th Ed., p 668

ASAE Standards. 49th ed. 2002 D245.5. Moisture relationships of plant-based agricultural products. St. Joseph, Mich.: ASAE.

Casada, ME. and Armstrong PR. 2008. Wheat moisture measurement with a fringing field capacitive sensor. *An ASABE meeting presentation*, Providence, Rhode Island. Paper number: 085207.

Chen, C. 2003. Evaluation of air oven moisture content determination methods for rough rice. *Biosystems Engineering* 86(4): 447-457. DOI: 10.1016/j.biosystemseng.2003.08.010

Maier, DE. 2015. Intervention strategies for the reduction of postharvest loss: Case studies. *Proceedings of the 1st International Congress on Post-Harvest Loss Prevention.* Urbana Champaign, IL: ADM Institute for the Prevention of Postharvest Loss, University of Illinois.

Obi, FO., Ezeoha, SL. and Egwu, CO. 2016. Evaluation of air oven moisture determination procedures for pearl millet (*Pennisetum glaucum* L.). *International Journal of Food Properties*, 19:2, 454-466, DOI: 10.1080/10942912.2015.1038566

Rai, AK., Kottayi, S., and Murty, SN. 2005. A low cost field usable portable digital grain moisture meter with direct display of moisture (%). *African Journal of Science and Technology Science and Engineering Series, 6*(1), 97-104.

World Bank 2011. Missing food: The case of postharvest grain losses in Sub-Saharan Africa. Report No. 60371-AFR.