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Use of moisture meter on the post-harvest loss reduction of rice

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Abstract

Moisture content is one of the most important factors determining grain quality during harvesting, storage, trading, processing, and transportation because high moisture will create problems for farmers, especially during postharvest activities such as mold growth, higher insect infestation, loss in seed germination, and low market price. A study was conducted to find out a precise moisture meter (MM) for moisture content (MC) determination during post-harvest activities of rice. John Deere moisture meter (JD MM), Moisture Probe and RiceterL MM were tested and calibrated to provide accurate result compared to that of Oven dry method. The average MC of same samples was found 11.4, 11.8, 12.3, and 13.1% by Oven dry method, Moisture Probe, RiceterL and John Deere MM, respectively. Standard deviations of the mean are 0.11, 0.17, 0.13 and 0.22, respectively by the corresponding moisture meters. Oven dry method i.e. drying whole kernels for 72 h at 105°C had the smallest standard deviation. This indicated long drying time and adequate drying temperature could ensure the precision of moisture determination. The reading of John Deere, Moisture Probe and RiceterL MM is higher by 1.7, 0.4 and 0.9%, respectively than that of oven dry method. Moisture measurement by these methods can lead to wide variations of conclusion. Moisture measurement by John Deere moisture meter is quicker and easier than Moisture Probe and RiceterL (MM). However, adjustment procedure with respect to calibration is needed before use.

Key words: Moisture meter, calibration, tool, post-harvest loss, reduction, rice

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Introduction

Moisture content (mc) is a critical parameter during harvesting, drying, storing, and sale of grains. If mc is too high in grain, there is a risk of quality reduction and losses in store. On the other hand, excessive drying is wasteful and can lead to reduced returns. Balancing these opposing risks is not easy due to the variable nature of grains within a bulk and the inherent difficulties of measuring grain moisture accurately. Hence, higher grain moisture affecting development of microorganisms in stored products. The possibility for farmers to sell their crops at a more favorable price has a positive effect on other low-income households as well. With local food supply no longer limited to harvest periods, price peaks on local markets are likely to decline. By adopting new storage techniques, farmers will contribute to less variable prices (Gitonga et al., 2012). Insufficient drying of crops prior to storage is another major problem. Retaining high moisture content will result in the grain increasing in temperature, due to respiration, which will also occur with increased insect and/or fungal activity. This heating leads to moisture condensation within the stored mass of grain, which in-turn creates favorable environment for additional fungal growth and insect infestation (Imura & Sinha, 1989). Traditional farmers use various subjective tests to determine whether grain is sufficiently dry to be stored. These tests usually work relatively poor and can lead to widely varying conclusions. Accurate measurement of grain moisture and timely drying could greatly reduce damage to grain caused by insect and mold activity during subsequent handling, storage and processing. Mold problems from mycotoxins are not only related to grain loss but also health, causing immune suppression, liver disease, cancer and likely stunting in children. Accurate moisture measurement and timely drying of maize can greatly reduce aflatoxin concentrations and ultimately lead to safer, higher quality and more nutritious food products for consumers (PACA, 2015). Moisture content should be in the suitable range (14% wb or less) for long-term storage. Too high moisture leads to deterioration in seed quality as a result of the microorganism growth and premature germination. In contrast, too low moisture can cause unnecessary energy consumption and crack seeds during drying the process. Seed is a living product that must be grown, harvested and processed to maximize its viability and subsequent crop productivity. For the yield potential of any rice variety to be realized, good quality seed must be sown. The extent of this increase is directly proportional to the quality of seed that is being sown. Seed quality can be considered as the summation of all factors that contribute to seed performance.

According to Davis (1944), the optimum harvest moisture content for the rce of the Caloro variety was 20-24%. Pominski *et al*. (1961), showed that the rice moisture content had a significant effect on milling yields of long grain rice. They selected samples with moisture content ranging from10-14% and concluded that for each 1% decrease in moisture content, head yields and total yields increased 3 and 0.7%, respectively. Dilday (1987) concluded that rice breakage decreased with increased rice moisture content.

Afzalinia *et al*. (2004) found that the moisture content had a significant effect on rice breakage of the whitener and the entire milling system so that the rice breakage decreased with increased rice moisture content. As mentioned by Luh (1991), the minimum total rice breakage occurred at the range of 12-14% moisture content; therefore this range was optimum moisture content for the rice and the milling time. It was reported by Peuty *et al*. (1994) that the rice drying conditions affected the breakage of rice during the milling process so that the rice breakage increased rapidly with decreasing moisture content of the air used to dry the Rice.

Moisture content of a feed usually is calculated as the weight lost by material during application of heat to a sample. Indeed, Thiex and Richardson (2003) proposed that the term "weight loss on drying" should be substituted for the term "moisture" when discussing feeds. Perkins (1943) noted that 4 to 7% more dry matter was lost from corn silage by 100° C drying than by toluene distillation. Fox and Fenderson (1978) found that DM of corn silage was underestimated by 8% and 11% by oven drying at 60 and 100° C, respectively. As discussed by Thiex and Richardson (2003), chemical water content should be measured by the Karl Fischer titration method.

Moisture meters may be available for small-scale farmers at extension services or public grain storage facilities, but most often farmers use indicative methods to find out if grain or seed are sufficiently dry, such as biting the grain with the teeth, pinching it between the fingers or shaking it. If the grain cracks and the kernels feel hard or make sharp sounds, the grain is dry enough for storage. If the grain is soft, it could mean it is still wet and needs further drying. Available moisture meters and probe measure an electrical property related to moisture content, rather than grain moisture itself. Meters and probes rely on an inbuilt calibration between moisture and either electrical capacitance or resistance. All probes and capacitance meters use whole grain samples. The Reduction of Post-Harvest Loss Innovation Lab has developed a proprietary moisture meter and also is working with John Deere to test more farmer friendly ways of estimating grain moisture content. John Deere moisture meter is rapid and easy to use. However, it must be calibrated by the standard moisture measurement method. Hence, the study was undertaken to calibrate JD MM with oven dry method and RiceterL MM and to find out precise moisture meter for accurate grain moisture measurement.

Methodology

The experiment was conducted at ambient condition in the Department of Farm Power and Machinery (DFPM) postharvest preservation and processing lab, Bangladesh Agricultural University (BAU) under the Postharvest Loss Reduction Innovation Lab (PHLIL) project.

Materials

The drying oven was Memmer model ULM 400 (Memmer Co., Germany) heated with forced-air circulation. The temperature control was within ±0.5°C. The control accuracy of inner temperatures was checked by a Hart 8C 227-2562 RTD thermometer (Hart Co., USA). The accuracy of this thermometer was 0.01°C as tested by the National Institute of Standards and Technology, USA (NIST). Moisture content of rice was determined by John Deere digital moisture meter, Moisture Chek PLUS^{TM}, SW08120 as shown in the following Figure 1. A digital balance (Model SHIMADZU BZ 32 OH, Japan) was used to weigh the samples. The accuracy of the balance was 0.001 g, as checked by METTLER 1585 standard weights. The standard weights were traced to E2 class weight standard, as calibrated by the National Measurement Laboratory, Taiwan. Medium-grain rough rice (BRRI dhan49) was harvested by a rice harvester at BAU agronomy farm. Rice was conditioned before mc determination. Each sample was about 3 kg, mixed thoroughly and sealed in a plastic container after cooling to room temperature. Samples were stored in a cooler at 28°C for 4 weeks to ensure moisture homogeneity. Before determining the moisture, containers of samples were taken out, kept in laboratory for 24 h to bring the grain temperature to the room temperature.

Figure 1. John deere moisture meter

Experimental procedures

The moisture determination procedures were adopted from the ASAE standard S352_1 (ASAE, 1982). The sample size was 15 g as moisture content below 25% was used. The whole grains or ground grains were placed in each of four moisture dishes. After weighing the dishes and grains, dishes and covers were placed in the oven. At the end of the drying period, the dishes were taken out and covered immediately. These dishes with covers were placed in desiccators until their temperature was cooled to room temperature. These dishes and covers were then weighed with a balance.

Standard procedure

In this study, drying whole grain in air oven using 105°C for 72 h was used as the base method to determine moisture contents of rough rice. The drying temperature was not too high so the volatile substance of dry material was not lost and the compositions would not be decomposed. The longer drying time could ensure that moisture could be removed from rough rice totally.

Standard deviation

At each moisture level, the average $\bar{y}$ and standard deviation s of measured values of moisture contents determined by different procedures were calculated. The standard deviation was calculated as

$$s = \sqrt{\frac{\sum (y_i - \bar{y})^2}{n-1}}$$

where: y_i is the measured value of moisture in %; $\bar{y}$ is the average value of measurement in %; and n is the number of samples.

Errors

Error of moisture determined was defined as

$E_r = M_a - M_t$

where: E_r is the error of moisture determined in %; M_a is the apparent moisture content for each procedure in %; M_t is the moisture content determined at 105°C for 72 h.

Results and Discussion

MC deviations of same rough rice sample

Moisture content deviations in four different methods of same rice sample are measured with the JD MM, Moisture Probe, RiceterL MM and Oven dry method are found 13.1, 11.8, 12.3 and 11.4%, respectively shown in Figure 2.

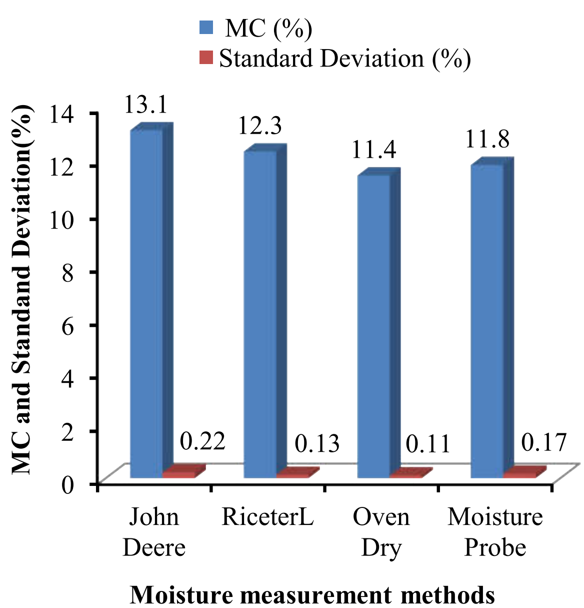

Figure 2. MC deviations of same rough rice sample determined by four methods

The RiceterL MM values are consistently below the John Deere meter. The least standard deviation is found in Oven dry method (0.11) followed by RiceterL MM (0.13), Moisture Probe (0.17) and JD MM (0.22). Oven dry method i.e. drying whole kernels for 72 h at 105°C had the smallest standard deviation. This indicated long drying time and adequate drying temperature could ensure the precision of moisture determination. In a separate study in the USDA lab in Manhattan, KS, similar values between the JD and PHL meter for wheat showed about the similar standard deviation compared to the standard oven method (Armstrong, 2015).

Standard errors of rough rice moisture contents based on oven dry method

Standard errors of determined rough rice moisture contents based on oven dry method are presented in Figure 3.

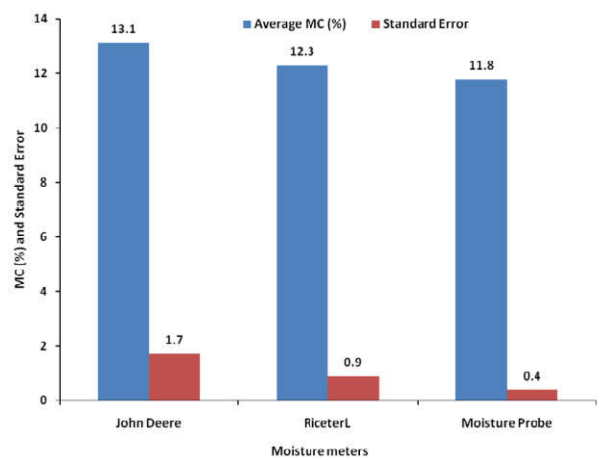

Figure 3. Standard errors of rough rice moisture contents based on oven dry method

Highest standard error (1.7) is found by JD MM followed by RiceterL MM and Moisture probe (0.4), respectively. All of the moisture meters can be used with respect to adjustment of standard error. To minimize errors a well-mixed, representative sample should be taken. Care should be taken to avoid contaminants.

Performance of Moisture Meters

John Deere Moisture Meter, Moisture Probe and RiceterL Moisture Meter were found easier in moisture content determination of rice. All of these give result quickly. These have several limitations such as breakage of rice, required specialized battery; and amount and condition of grain sample. In case of RiceterL MM tested grain sample is broken; JD MM, 9 ampere battery is required which is not commonly found; Moisture probe, only in-vitro grain sample can be measured as shown in Figure 4. Comparative advantages of moisture meters are given in Table 1.

Figure 4. Sample tested by different moisture meters

Considering results outcome, condition of tested grain, portability and power requirements of operation John Deere moisture meter is better than other moisture meters. Most often farmers use indicative methods to find out if grain or seed are sufficiently dry, such as biting the grain with the teeth, pinching it between the fingers or shaking it. If the grain cracks and the kernels feel hard or make sharp sounds, the grain is dry enough for storage. However, all farmers cannot judge accurately and these practices lead to higher moisture content in grain storage which favors rapid insect infestation and postharvest losses (Shahjan, 1975 and Howlader *et al*. 2004). As a result, they have to sell earlier at lower prices; benefits go to middle man, hoarders. These losses can be minimized by reducing mc at optimum level with the use of precise moisture meter during post-harvest activities.

Table 1. Comparative performance of moisture meters over oven dry methods

Parameters	John Deere MM	Moisture Probe	RiceterL MM	Oven Dry Method
Results outcome	Quick	Slow	Quick	Time consuming
Tested Grain	Good	Good	Brocken	Good
Convenience	Portable	Portable	Portable	Stationary
Power required	9 V	9 V	1.5 V	220 V
Standard Deviation (%) of results	0.22	0.17	0.13	0.11

Conclusion

Moisture content measurement is important to farmers for safe grain storage. If grain moisture is too high, there is a risk of quality reduction and losses in store. However, these losses can be mitigated by reducing mc at optimum level using appropriate moisture meter during post-harvest activities. MC measured by John Deere, RiceterL MM and Moisture Probe was higher by 1.7, 0.9 and 0.4%, respectively than that of oven dry method. Moisture meters provide an easy, convenient and precise way to measure grain moisture content. It would enable grains to be precisely dried, and thereby lower storage losses, increase smallholder livelihoods and enhance food security. An economic benefit of safe grain storage is that farmers can sell their produce at any time with desired prices; this increases farmers' bargaining power, as they have the option to delay selling. This will help farmers get a fair price for their produce and limit the role of middlemen and hoarders.

Further, safe storage can also help farmers to access credit: farmers can pool their produce, store and then sell as good quality and large volumes. John Deere MM is quicker and easier in MC measurement than Moisture Probe and RiceterL MM. These can be used with respect to calibration.

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