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FIELD TESTING OF GRAIN PROBE MOISTURE METER

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ABSTRACT

A frequency-based capacitance type grain probe moisture meter was developed as a low-cost alternative tool for accurate and rapid moisture content measurement of paddy and corn in bags. The prototype unit consisted of a standard grain probe, a 100-gram capacity test chamber, a grain selector menu panel for control and measurement and a handle for ease of sampling. Calibration models between frequency and moisture contents were established and validated with a relatively high coefficient of determination (R^2) of 0.94 and 0.97, for paddy and corn, respectively. Laboratory and actual field testing conducted between moisture content readings of grain probe moisture meter and standard reference oven method resulted to mean absolute error of 0.24 and 0.34 for paddy and corn, respectively.

Likewise, field testing results in Bulacan, Isabela and Nueva Viscaya revealed a mean % error of 3.9 % for paddy and 3.2 % for corn, respectively. This is an indication of acceptable level of accuracy. Initial fabrication cost of the prototype unit of grain probe moisture meter was approximately PhP 5,500.00. The prototype grain probe moisture meter has the advantage of simultaneously performing grain sampling and moisture content determination.

INTRODUCTION

Moisture content and purity are primary quality factors which serve as the basis for payment of commodity being sold. These are therefore properly determined at every point of postharvest handling. The accuracy of moisture content level in a product is very critical especially when transactions are based on weight. Small errors in measurement can have significant consequences (Sampang, 1992).

In the Philippines, private traders-millers and the National Food Authority (NFA) usually use only two parameters in pricing grains. These are moisture content and purity or cleanliness (www.nfa.gov.ph). The Equivalent Net Weight Factor (ENWF) table, derived from moisture content level of grains was used by NFA in the determination of paddy and corn procurement prices.

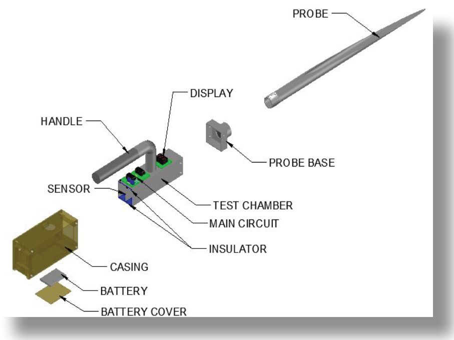
The most common and practical method of moisture content determination in the country is empirical, without using any device. The method involves nibbling of grains and crushing between fingers. Others rely on the smell of dull or sharp rattle produced by shaking a few grains in a box. While this practice was a popular choice among farmers, traders and processors, these methods do not give a true objective measurement, but only estimate the degree of moisture by subjective sensory perception (Semple et.al, 1988). Moreover, such method is prone to abuse. The classifier may misclassify the moisture content of the grain to the disadvantage of the seller.

Similarly, a typical grain handling operation in the Philippines is not possible without the use of a sampling probe, locally known to the industry as *"buriki".* It is a tool used mostly by agents and classifiers to collect grain samples like paddy, rice and corn from randomly selected bags. Collected samples using *buriki* were initially assessed for purity, damaged and discolored kernels by ocular inspection. Moisture content is then assessed using empirical method or if available, moisture meters. This method besides being subjective entails double handling and in most cases prolongs procurement operation. *Buriki* is also used to facilitate periodic monitoring of stored grains (Ramos, et.al. 2015)

In 2015, PHilMech attempted to integrate a moisture sensing mechanism to the popular tool, *buriki* and came up with a prototype unit grain probe moisture meter. This technology aimed to provide an alternative tool to address the subjectivity and long process of empirical method of moisture content determination of grains in bags.

The prototype unit comprised of a standard probe, a 100-gram capacity test chamber, a menu panel for overall control and measurement and a handle for ease of sampling. It featured a micro-controller based processor and a 7-segment 3 digit LCD screen.

CAD drawing of the prototype unit is shown in Figure 1.Figure 2 shows the actual picture of the prototype grain probe moisture meter. It was initially designed to measure content of paddy and corn.



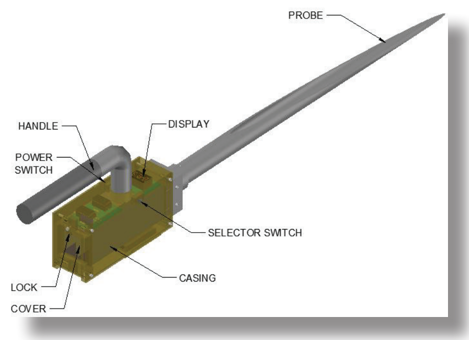


Figure 1. CAD plates of the prototype probe moisture meter

Figure 2. The prototype grain probe moisture meter

Calibration tests (as shown in Figure 3) conducted between frequency readings and standard oven moisture content measurements of paddy and corn yielded strong linear relationships. Calibration models were established with relatively high correlation of determination (R^2) of 0.94 and 0.97 for paddy and corn, respectively. Also, a comparatively low standard error of estimates (SEE) of 0.87and 0.85 were established for paddy and corn, respectively. This is an indication of excellent fit of the prototype system design.

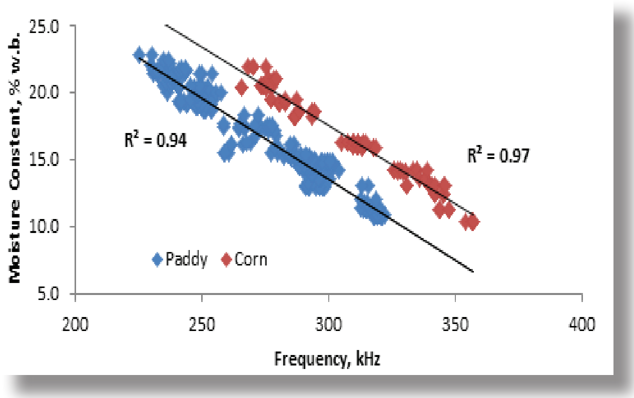


Figure 3. Calibration data generated from laboratory experiments for paddy and corn

Preliminary validation tests have demonstrated that the calibration models of the prototype grain probe moisture meter were adequate in predicting moisture content of both paddy and corn grains. Likewise, operational and functional requirement were initially evaluated in Nueva Viscaya resulting to positive reviews and recommendations of the potential end users.

This paper presents the validation tests and field testing results to evaluate the technical performance of the developed prototype grain probe moisture meter in actual field conditions.

OBJECTIVES

General:

This project aimed to assess the technical and socio-economic performance of the prototype grain probe moisture meter and recommend if necessary, the development of a commercial prototype grain probe moisture meter.

Specific:

1. To evaluate the technical performance of the prototype grain probe moisture meter in actual field conditions;
2. To evaluate the financial and social acceptability of the prototype unit; and
3. To come up with a recommended design of a commercial prototype grain probe moisture meter.

METHODOLOGY

Description of the prototype grain probe moisture meter

The prototype unit of the grain probe moisture meter is comprised of a standard probe; a constant 100-gram capacity test chamber where samples to be measured are placed; a sliding on/off power switch and a grain selector for overall control and measurement. It is also provided with a handle for ease of handling. It has a total length of about 630 mm, 42 mm width and aggregate weight of 730 grams without load (Figure 4).

Grain Selector Switch

LCD Display

Figure 4. Salient features of the prototype grain probe moisture meter

The prototype circuit system is described in a functional block diagram in Figure 5. Stainless steel parallel plates separated by a computed distance and encased in an acrylic plastic acted as capacitance sensor. The grains to be measured were placed in the test chamber and acted as the dielectric medium of the parallel plate capacitor. The prototype unit probe moisture meter adopted a capacitive sensor oscillator circuit. It used precision resistors in determining the capacitance of the grain samples placed inside the test chamber. The oscillator circuit was connected to a microcontroller to measure the frequency generated. The microcontroller would convert the frequency reading into moisture content values based on the calibration equation developed. The computed moisture content values were transmitted to a 7 segment, 3-digit LED screen. The supply voltage for the circuit was a 3.7V Lithium-ion rechargeable battery.

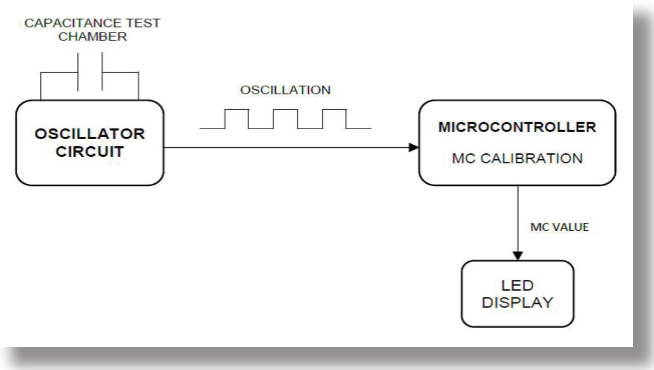


Figure 5. Functional block diagram of the prototype grain probe moisture meter

Technology performance evaluation

This activity was conducted to establish the operating characteristics of the prototype grain probe moisture meter. Procedures were divided into two stages: laboratory experiment and actual field testing.

Laboratory experiments

The prototype unit of the probe moisture meter was evaluated in a controlled laboratory setting for precision, accuracy and operating range of temperature (Figure 6). Measured moisture contents were compared to oven-dried samples based on ASAE Standards (2000) moisture content determination method. A total of 30 and 81 samples with different moisture content levels were used as test samples for paddy and corn, respectively. Moisture content of the paddy samples ranged from 8.90% to 17.40% while corn samples ranged from 10.60% to 15.50%.

Figure 6. Actual laboratory experiments of the prototype grain probe moisture meter

Precision and accuracy were tested using 16 and 14 levels of moisture content for paddy and corn, respectively, based on the provisions of the National Institute for Standards Technology (NIST) Handbook 44 (2015). The provision indicated a test of at least three replicates per sample and at least two levels of moisture contents for a testing to be standard.

On the otherhand, this project complied to the Unified Grain Moisture Algorithm (UGMA) of the United States Department of Agriculture (USDA) which requires an average difference for at least six samples (USDA, 2017).

Each sample with varying moisture content was measured in 10 replicates.Precision was computed using mean error, range and standard deviation (Std. Dev). Range was expressed by the difference between the highest and lowest moisture content readings of the grain probe moisture meter with the below equation' while Std. Dev. was computed for all population using standard equation of Windows Excel software.

$$Range = MC_{max} - MC_{min} \quad (1)$$

where:

MC_{max} = the highest moisture content value attained by the grain probe moisture meter within the 10 replicates, %

MC_{min} = the lowest moisture content value attained by the grain probe moisture meter within the 10 replicates, %

On the other hand, percentage error as a function of accuracy was measured using the below equation as cited by Sayed Hassen (2006):

$$\%\ Error = \frac{ABS\ (Reference\ MC - Measured\ MC)}{Reference\ MC} \times 100\% \quad (2)$$

where:

Reference MC = MC reading using oven-dry method, %w.b.

Measured MC = MC readings of grain probe MC meter, %

Effects of temperature as well as purity of the samples against accuracy were also observed to establish the operating range workable for the prototype grain probe moisture meter. Since no conditioning chamber is available to vary the temperature, the observations were limited to the actual temperature readings at the time of each testing.

Actual field testing

A total of 10 cooperators were initially selected for the project. Five of the listed potential cooperators were from the National Food Authority (NFA); two from Isabela (Santiago and Echague), one each from Cabanatuan City, Nueva Ecija and two from Pangasinan (Binalonan and Lingayen). Also, two trader-rice millers were selected from Pangasinan (Bayambang, Mangatarem) and Bulacan (San Rafael, Bocaue), respectively. Only one farmer's cooperative (Nueva Vizcaya) engaged in grains trading and rice milling was selected. However, because of limited samples and procurement operations, only three cooperators with sufficient data available were considered in the technical evaluation. Recommendations and observations of the other three cooperators were all considered. Northern Luzon Grains Processing Center (NGPC) in Echague, Isabela provided data for both paddy and corn, while a cooperative in Nueva Viscaya and a ricemiller-trader in Bulacan both provided data for paddy.

Technical performance evaluation in terms of accuracy and precision were conducted based on the actual utilization data provided by the cooperators. A trained classifiers in charge of procurement operations were selected and trained on the operations prior to the testing. Data sheets were given to cooperators to record comparative moisture readings between the prototype grain probe moisture meter and their existing MC meters. A conversion table of the cooperators' existing MC meter readings to equivalent oven moisture content were established before the testing and served as basis of evaluation. For paddy, a total of 25, 15 and 6 moisture content readings were gathered and evaluated for Bulacan, Isabela and Nueva Viscaya respectively while six moisture content readings were evaluated for corn from Isabela cooperator. Equations used for the computation were the same as the equations used for laboratory testing.

Assessment for financial and social acceptability

Factors considered in financial assessment of the study were the fabrication cost of the technology, scale of operation and cost of operation, among others. Initial fabrication cost of the prototype grain probe moisture meter was done to give an idea to the potential end users of the technology's affordability, offering an inexpensive alternative to imported moisture meters.

On the otherhand, social acceptability was documented based on the cooperators' feedbacks in terms of operational and functional management and requirement of the potential users. Cooperators were also encouraged to recommend perceived additional features of the prototype grain probe moisture meter to address specific needs of the industry's key players in grains trading.

RESULTS AND DISCUSSION

Financial and social acceptability of the prototype grain probe moisture meter

Paddy

Figure 7 shows the comparison of moisture content readings of paddy samples between the prototype grain probe moisture meter and oven-dried moisture determination method. In general, it was observed that the moisture meter readings followed closely the moisture content determined by the air oven method.

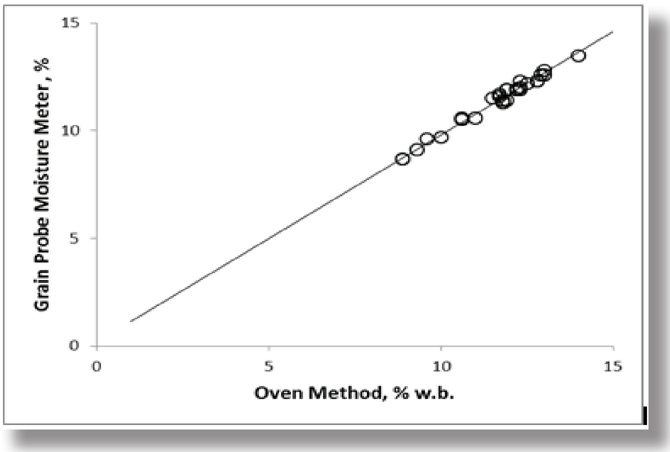


Figure 7. Comparison of paddy moisture content readings between oven method and grain probe moisture meter

Likewise, test results given in Table 1 indicated the technical viability of the grain probe moisture meter tested for paddy samples with 16 levels of moisture contents. Range as a function of precision was computed to be 0.16% while mean error and % error was measured to be 0.24 % and 2.0 %, respectively. This was within the 0.8 % mean error and 5 % error standards set (NIST, 2015; Stubsgaard, 1997).

Table 1. Laboratory test result of paddy moisture content readings between reference oven method and the prototype grain probe moisture meter

Moisture Content			%		
		Abs	Error		
Oven, % w.b.	Probe MC Meter %	Error	(Accuracy)	Std. Dev.	Range
17.40	17.10	0.30	1.72	0.30	0.25
14.00	13.50	0.50	3.57	0.50	0.21
13.00	12.70	0.30	2.31	0.14	0.20
12.90	12.60	0.30	2.33	0.30	0.30
12.80	12.30	0.50	3.91	0.00	0.00
12.50	12.20	0.30	2.40	0.30	0.30
12.30	12.15	0.15	1.22	0.21	0.14
12.20	11.90	0.30	2.46	0.00	0.30
11.70	11.65	0.05	0.43	0.07	0.10
11.50	11.50	0.00	0.00	0.00	0.00
11.00	10.60	0.40	3.64	0.40	0.14
10.60	10.55	0.05	0.47	0.07	0.10
10.00	9.70	0.30	3.00	0.30	0.30
9.60	9.60	0.00	0.00	0.00	0.00
9.30	9.10	0.20	2.15	0.20	0.20
8.90	8.70	0.20	2.25	0.00	0.00
	Average	0.24	1.99	0.17	0.16

** Average of 10 replicates*

Corn

For corn, 81 moisture content data points were generated to compare the performance of the grain probe moisture meter with the reference oven method (Figure 8). Again, it was observed that the moisture meter readings closely followed the moisture content determined by the air oven method.

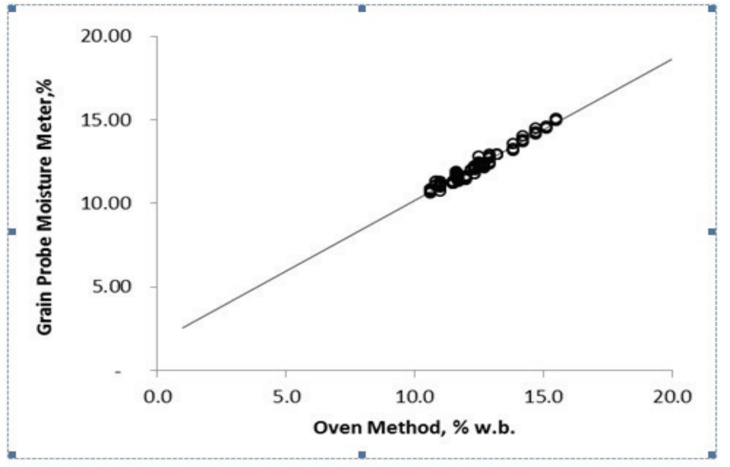


Figure 8. Comparison of corn moisture content readings between oven method and grain probe moisture meter

Furthermore, laboratory test results (Table 2) generated an indicative accuracy of the grain probe moisture meter for corn. Range as a function of precision was computed to be 0.28% while mean error and % error was measured to be 0.34 % and 2.59 %, respectively. This was also within the 0.8 % mean error and 5 % error standards set (NIST, 2015; Stubsgaard, 1997).

Table 2. Laboratory test result of corn moisture content readings between reference oven method and the prototype unit grain probe moisture meter

Moisture Content		(Accuracy)			
		Mean	%Error		
Oven, % w.b.	Probe MC Meter %	Error		Std. Dev.	Range
10.60	10.74	0.14	1.32	0.11	0.23
10.80	11.18	0.38	3.52	0.14	0.23
11.60	11.77	0.17	1.47	0.13	0.59
11.70	11.42	0.28	2.39	0.10	0.70
12.00	11.53	0.47	3.92	0.10	0.23
12.20	12.03	0.17	1.39	0.00	0.00
12.30	11.91	0.39	3.17	0.18	0.47
12.70	12.29	0.41	3.23	0.10	0.23
13.20	13.00	0.20	1.52	0.24	0.00
13.80	13.43	0.37	2.68	0.18	0.35
14.20	13.79	0.41	2.89	0.13	0.35
14.70	14.25	0.45	3.06	0.15	0.35
15.10	14.75	0.35	2.32	0.08	0.12
15.50	14.98	0.52	3.35	0.08	0.12
	Average	0.34	2.59	0.12	0.28

Effect of temperature and purity on the accuracy of the prototype unit grain probe moisture meter

Temperature

Temperature is one critical factor when using capacitance sensors (Nelson, 1991; Rai, 2005; Stubsgaard, 1997). A test was conducted to evaluate the effect of temperature to the performance of the grain probe moisture meter. With actual temperature ranging from 21.8^{o}C to 32.7^{o}C, accuracy of the grain probe moisture meter was not significantly affected as indicated in the regression analysis conducted between temperature readings and mean error of measurements.

Results showed a very low R^2 of 0.20 indicating very low relationship between temperature and accuracy. Likewise a *P* value of 0.28 was computed indicating no significant relationship between temperature readings and mean error of measurement of moisture contents at 5% level of confidence. Moreover, the mean error as well as the % error was way below the 0.8 % and 5% moisture reading, respectively, the minimum errors as per NIST Standards. These findings were consistent to Stubsgaard (1997) observation that no temperature correction might be needed within the temperature range of 10 to 30°C.

Because of insufficient samples, the same test was not conducted for corn.

Purity of Grain Samples

Accuracy of the grain probe moisture meter was also tested with different levels of purity of paddy samples. Actual samples measured for moisture content reading were the same samples used for the test.

Spread of data generated for 35 measurement points (Figure 9) seemed to indicate an acceptable level of accuracy for purity level ranging from 94% to 100%. The spread of mean error of measurement against purity were all within the acceptable mean error of 0.8%. A more consistent accuracy however was observed at purity levels 99% and higher. The observed mean error that tended to be negative values at lower purity range and positive values at higher purity range seemed to indicate significant effect but results of regression analysis has proven otherwise with an R^2 of 0.03 and P value of 0.32. The same test was not conducted for corn since presence of corn impurities were not observed in the actual samples inside the probe.

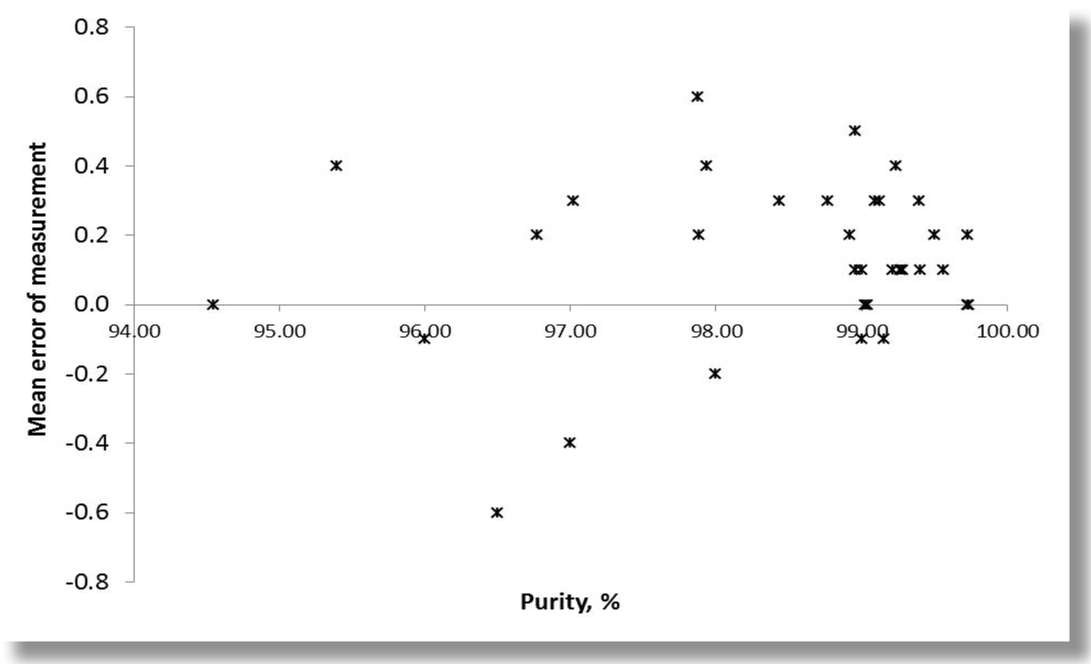


Figure 9. Effect of paddy purity level against mean error of measurement

Based from the tests conducted, technical specifications of the prototype unit of the grain probe moisture meter for paddy and corn was established and is given in Table 3. The prototype grain probe moisture meter was initially calibrated for paddy and corn with moisture content range of 8% to 20% with mean measurement error of 0.24% for paddy and 0.34% for corn and % error of 2.0% and 2.6% for paddy and corn, respectively.

Table 3. Technical specifications of the grain probe moisture meter for paddy and corn

Particulars	Parameters	Standard1
Measuring principle	Capacitance	-
Applications	Paddy and corn grains	-
Measuring range	8% - 20%	Varies
Resolution	0.10%	0.1% for commercial, 0.01% for calibration
Operating temp. range[2]	21 - 33˚C	10 - 40˚C, minimum
Moisture respond speed	< 5 seconds	Not indicated
Mean error	Mean MC ±0.24% (Paddy) Mean MC ±0.34% (Corn)	±0.8%
% error	Mean MC 2.0% (Paddy) Mean MC 2.6% (Corn)	5%
Sample size	100 grams	100 grams or 400 kernels/seeds
Type of display	3-digit 7 segment display	Varies
Power supply	3.7V lithium-ion battery	Varies
Unit size with probe, mm w/out probe, mm	630 x 50.60 x 70.40 180.7 x 50.60 x 70.40	- -

[1] *Based on National Institute for Standards and Technology (NIST) Handboook.44*

[2] *Based on completed trials*

Actual Field Testing

Table 4 shows the summarized field test results from the three cooperators in Bulacan, Isabela and Nueva Viscaya. Results of precision and accuracy revealed comparable findings with the laboratory results. Nueva Viscaya test result was found to have the lowest mean error of 0.52% and % error of 5.6% that might have caused by the least number of measurements yet widest ranges of moisture content including the highest at 23.7%. On the other hand, test result in Bulacan yielded the highest accuracy with mean error of 0.27% and % error of 1.90% having the most number of measurements. All three, however, conformed to the required tolerances and allowable measurement errors set.

The same findings were found from the test conducted for corn samples with mean error of at 0.18% and % error of 3.2%.

Table 4. Summary of field test results conducted for the prototype grain probe moisture meter

Testing Site	Mositure Content Range, %[1] Equivalent Oven	Grain Probe MC Meter	- Mean Error	% Error (Accuracy)	- Std. Dev.	- Range
PADDY						
Bulacan	10.25 to 14.50	10.0 to 14.0	0.27	1.90	0.02	0.23
Isabela	8.34 to 11.74	7.9 to 12.0	0.20	4.10	0.27	0.44
Nueva Viscaya	8.5 to 23.7	8.1 to 23.6	0.12	5.60	0.37	0.52
CORN		***Average***	***0.20***	***3.90***	***0.22***	***0.29***
Isabela	10.50 to 12.00	10.30 to 11.70	0.18	3.20	0.15	0.36

[1] *Average of 25, 15 and 6 measurements from Bulacan, Isabela and Nueva Viscaya, respectively*

[2] *Average of 6 measurements from Isabela*

Among the reported type of moisture meters, it seemed that price is directly proportional with accuracy and reliability as shown in Table 5. Assessment of moisture content readings of existing moisture meters to oven method showed that MC Meter B (single grain type moisture meter) had the lowest average MC difference of 0.55% while MC Meter A, had the highest MC difference of 3.66%.

Table 5. Market price and oven moisture content calibration of cooperators' existing moisture meters for grains

Moisture meter*	Price, Php	Moisture Content Difference from Oven Method, % w.b. *Range, %*	*Average*
MC Meter A	35,000.00-65,000.00	2.0 to 7.25	3.66
MC Meter B	200,000.00-250,000.00	0.5-1.0	0.55
MC Meter C	None, Phased out	-	-
MC Meter D	13,500.00-16,000.00	±1.25 to 2.5	1.85

* MC Meter A=Portable/handheld moisture meter; MC MeterB2=Single grain moisture meter

Financial considerations in the utilization of grain probe moisture meter

The prototype grain probe moisture meter has lower capital investment compared with existing moisture meters in the grain industry. The fabrication cost of the prototype unit amounted approximately PhP 5,500 pesos including labor cost. This is competitive with existing imported popular brands of grain moisture meters which has an investment cost ranging from Php 40,000.00 to Php 250,000.00. In addition, the prototype grain probe moisture meter has the advantage of simultaneously perform grain sampling and moisture content determination.

Results of the field testing of the prototype grain probe moisture meter revealed that all cooperators considered moisture content as primary consideration in their procurement, drying, milling and storage decisions followed by grain quality. It was reported that very high or very low grain moisture contents both affect the economic returns to the seller-farmers and buyers. Therefore, it is very important for grain stakeholders to manage grain moisture content and market the commodity at acceptable market standards to optimize economic or financial return.

Table 6 shows the assumptions used to demonstrate the estimated monetary value of inaccurate MC determination during paddy trading. When examining the potential monetary loss per bag in paddy procurement, using the ENWF of NFA and the lowest 2% MC difference, about Php 23.80 per bag would be lost to the seller for inaccurate moisture evaluation.

Table 6. Assumptions used and the estimated monetary value of inaccurate MC determination

Item	Value
Buying price, Php/kg at 14% MC	17.00
Weight of paddy, kg	50.00
Actual MC, %	14
MC reading at the buyer, %	16
MC reading difference, %	2
Weight discounts/loss	1.16
Discounted price/weight factor	16.524/.972
8. Monetary value of inaccurate MC determination*, Php/bag	**23.80**

*Price per bag x Net weight of paddy x ENWF = Value per bag

As noted, the apparent MC difference of existing moisture meters per bag seemed insignificant. However, if this MC difference is transformed on per truck load basis or larger scale, the economic impact of the potential loss due to inaccuracy of MC determination would be substantial in the grain sector.

Acceptability of the prototype grain probe moisture meter

During field testing of the probe moisture meter, six of the cooperators reported that the equipment can rapidly and accurately measure the moisture content of paddy and corn. Likewise, the grain probe meter can potentially save time and effort in moisture assessment. Most importantly, the unit ensure the procurement of quality grains, ease in MC monitoring of stocks during storage and MC validation before storage and milling.

Table 7 shows the perception of cooperators or the first time users during the field testing of the probe moisture meter at selected provinces. Two trader-rice millers were more interested in moisture meter for milled rice than moisture meter for palay or corn while four cooperators wanted that the probe moisture meter reading be adjustable to some degree (2% to 7%) than the actual reading to suit specific trading system. While, this feature is attainable and might be beneficial to some players of the industry, this abusive tendency might harm other key industry players.

Table 7. Summary of comments and perception of potential end users of the grain probe moisture meter

Item	Comments	
	Positive existing features	**Suggested additional features**
Cooperators (6)	• Rapid reading • Rapid and accurate • Simple and easy to use • Gender-friendly • Light • Give specific MC • Can be used in outside procurement, monitoring of stocks and validation of MC before milling	• Adjustment of program to higher MC of 2% to 7% • Interested in MM for rice
Others (4)	• Convenient to use with bags loaded at the truck • Can be used for MC checking and verification	• Interested in MM for rice • Might find difficulty shifting from traditional method to this new technology • Adjustment of program to higher MC of 2% to 7%

SUMMARY, CONCLUSION AND RECOMMENDATION

A frequency-based capacitance-type grain probe moisture meter was designed, developed and tested for accurate and quick moisture content measurement of paddy and corn in bags. Calibration models between frequency and moisture content were established and validated with a relatively high correlation of determination (R^2) of 0.94 and 0.97, for paddy and corn, respectively.

Likewise, field test results in Bulacan, Isabela and Nueva Viscaya revealed a measurement error of 0.20% for paddy and 0.18% for corn, respectively and % error of 3.90% and 3.20%, respectively, for paddy and corn. This is an indication of acceptable level of accuracy and compliance with existing standards set by NIST, a reputable institution under the U.S. Department of Commerce tasked to promote equitable standards worldwide.

Initial fabrication cost of the prototype grain probe moisture meter was approximately PhP 5,500.00. This is competitive since existing imported popular brands of grain moisture meters have investment cost ranging from Php 40,000.00 to above Php 100,000.00. In addition, the prototype grain probe moisture meter has the advantage of simultaneously performing grain sampling and moisture content determination.

Thus, the grain probe moisture meter can save time and effort in moisture assessment. Most importantly, it ensures the procurement of quality grains, ease in MC monitoring of stocks during storage and MC validation before storage and milling. Potential commercialization will also open doors of business opportunity for the local manufacturers.

Likewise, calibration of the prototype grain probe moisture content meter to paddy and corn with higher moisture content level as well as milled rice should be done to cater to other operating requirements of potential end users.

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APPENDIX

Estimated Fabrication Cost of the prototype unit grain probe moisture meter

[redacted]	[redacted]
ITEM/DESCRIPTION	UNIT COST
1. Electronic parts/components	1,548.75
2. Test Chamber	1,076.14
3. Probe	463.85
4. Other Accessories (Battery, switch, etc)	1,136.00
[redacted]	[redacted]
Total Material Cost :	4,224.74
Estimated Labor Cost:	1,267.42
Total Fabrication Cost:	5,492.16

NOTES

About PHilMech

The Philippine Center for Postharvest Development and Mechanization, known then as the National Postharvest Institute for Research and Extension (NAPHIRE), was created on May 24,1978 through Presidential Decree 1380 to spearhead the development of the country's postharvest industry.

As a subsidiary of the National Grains Authority in 1980, the agency's powers and functions were expanded in line with the conversion of NGA to the National Food Authority.

In 1986, PHilMech moved to its new home at the Central Luzon State University compound in Muñoz, Nueva Ecija.

The agency was transformed from a government corporation into a regular agency through Executive Order 494 in 1992. It was renamed the Bureau of Postharvest Research and Extension (BPRE).

For years now, PHilMech is engaged in both postharvest research, development and extension activities. It has so far developed, extended and commercialized its research and development outputs to various stakeholders in the industry.

With Republic Act 8435 or Agriculture and Fishery Modernization Act (AFMA) of 1997, PHilMech takes the lead in providing more postharvest interventions to empower the agriculture, fishery and livestock sectors.

Pursuant to Executive Order 366 or the government's rationalization program in November 2009, BPRE became the Philippine Center for Postharvest Development and Mechanization (PHilMech) with twin mandates of postharvest development and mechanization.

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