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Evaluation Report 217

Dickey John Forage Moisture Tester

A Co-operative Program Between

ALBERTA FARM MACHINERY RESEARCH CENTRE

PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

DICKEY-JOHN FORAGE MOISTURE TESTER

MANUFACTURER:

Dickey John Corporation
P.O. Box 10
Auburn, Illinois
626156 U.S.A.

DISTRIBUTOR:

RETAIL PRICE: $355.00 (June 1981 f.o.b. Portage la Prairie, Manitoba).

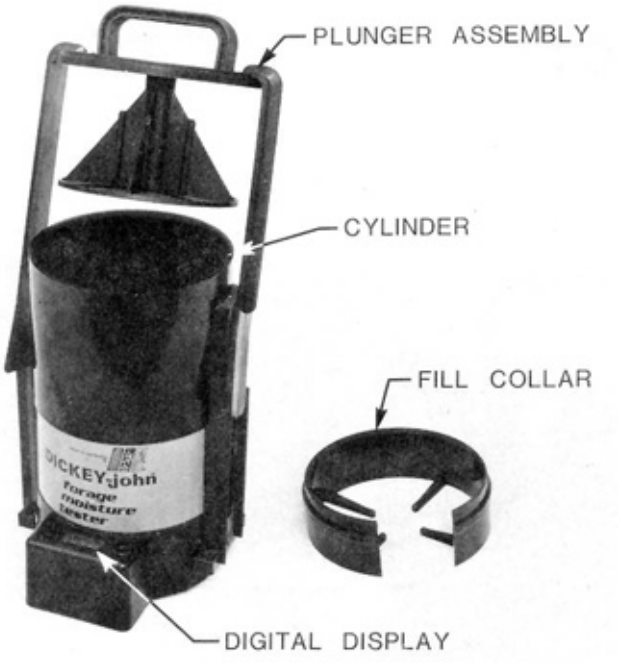

FIGURE 1. Dickey-John Forage Moisture Tester.

SUMMARY AND CONCLUSIONS

Functional performance of the Dickey-John forage toolsture tester was *very good,* however the accuracy of supplied moisture conversion tables was *unsatisfactory* for alfalfa and *fair* for corn.

Recalibrating was necessary to correctly read moisture content for prairie forage crops. In chopped alfalfa, the moisture conversion tables indicated moisture contents which varled from accurate readings (at 20% moisture content) to 25% low (at 76% moisture content). In chopped corn, the conversion table indicated moisture contents varying from 5% low (at 40% moisture content) to 6% low (at 72% moisture content).

It was best to average measurements from several samples in each forage batch to reduce errors from moisture variation within the forage. The errors were red uced from an average of ±13% in chopped alfalfa and ±12.5% in chopped corn for single sample measurements to an average of ±2.0% for both crops by averaging several measurements. Meter repeatability was *good* in both alfalfa and corn.

Operating ease was *excellent.* The Dickey-John was convenient to use in the field. Best results were obtained with uniformly chopped forage samples. A single moisture determination took about four minutes.

The original battery lasted the duration of the test.

RECOMMENDATIONS

It is recommended that the manufacturer consider providing moisture tables suitable for typical prairie forage crops.

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THE MANUFACTURER STATES THAT

The dielectric properties of sim ilar forages often vary due to uncontrollable factors. However, the relationship between dielectric properties and moisture will remain predictable for a given crop.

Our charts attempt to average these variations. The user should periodically check his results against a standard so that the appropriate corrections can be made. Development of our charts is concentrated on the most popular crops. Recognizing that some users have special applications, we have prepared procedures to formulate calibration charts. These are available from the manufacturer.

Note: This report has been Prepared using SI units of measurement. A conversion table is given in APPENDIX III.

GENERAL DESCRIPTION

The Dickey-John is a portable, electronic forage moisture tester. It determines moisture content by measuring electrical capacitance.

The 150 mm (6 in) diameter cylinder is filled with chopped forage and compressed. A meter reading is taken when suitable pressure has been applied to the container. Moisture content is then determined from appropriate conversion tables. The Dickey-John has an automatic temperature compensation.

The Dickey-John is supplied with conversion tables for typical chopped forage and grains. Instructions are included for developing conversion charts for other crops.

The tester operates on a 9V transistor battery and is equipped with a carrying handle and plastic pouch for the conversion tables.

Detailed specifications are given in APPENDIX I.

SCOPE OF TEST

The Dickey-John was used to determine moisture contents of a variety of chopped alfalfa and corn forages. Meter readings were compared to moisture contents obtained using a standard oven method[1]. Samples were collected from a large number of fields at various stages of crop maturity. The moisture contents of four representative samples were measured from each batch. In total, more than 250 forage samples were tested with the Dickey-John.

The Dickey-John was evaluated for ease of operation, quality of work and suitability of the operator manual.

RESULTS AND DISCUSSION

EASE OF OPERATION

Portability: The Dickey-John was easy to use. It was light and portable, with a self-contained power source, making it convenient for field use. The tester did not have to be levelled since sample weighing was not needed.

Sample Selection: One of the main problems in forage moisture measurement is obtaining a representative sample. The operator manual detailed clear instructions for preparing a suitable sampie. It indicated that best results were obtained by taking the average of at least three sample readings.

Best results were obtained using uniformly chopped forage samples of about 20 mm (0.75 in) cut length. Chopped samples from a forage harvester were suitable for direct measurement. Standing or windrowed crop samples had to be chopped before testing. Shears were used to prepare suitable samples from unchopped hay.

Operating Procedure: The sample cylinder is hand filled, with a representative forage sample, to the top of the fill collar. The fill collar is removed and the plunger assembly is inserted to compress the sample. The proper amount of forage has to be loaded into the cylinder so that the plunger assembly does not lock into position before the pressure indicator switch (incorporated in the

[1] *PAMI T7830 Detailed Test Procedures for Forage Moisture Testing Devices.*

base of the tester) is activated. After the compressed sample has stabilized for about 20 seconds, the button near the indicator is pressed and a temperature compensated reading appears. The cylinder is then emptied and the moisture content, corresponding to the tester reading, is read from the conversion chart. A single moisture measurement can be completed in about four minutes.

Controls: The Dickey-John had a push button key which activated the temperature compensator. This switch had a tendency to stick when depressed, necessitating care to see that it was released. The built-in switch in the base of the tester activated the sensor for moisture content readings. Battery voltage was checked by activating the indicator switch by applying a downward force to the plunger with the empty cylinder.

Battery: The battery needed replacement, at the end of the test, after measuring about 250 samples. Battery replacement was convenient.

Cleaning: The Dickey-John was convenient to clean due to the easy access to the large sample cylinder and plunger assembly.

QUALITY OF WORK

General: Chopped forage is a non-uniform material. As detailed in the operator manual, it was important to obtain a representative sample of forage for moisture determination. Since large variations in moisture content may occur throughout a field, several samples should be taken from a large representative sample or batch of forage to get a good indication of the average moisture content in the field.

The dielectric properties of similar forages may also vary, due to many uncontrollable factors such as crop variety, geographical location, maturity and weathering. The manufacturer's charts and tables are an attempt to accurately represent average properties for one crop type. However, it is difficult to predict the dielectric properties of one crop type and accurately present them in a single table.

Range of measurement: The tables supplied with the Dickey-John indicated that it was capable of measuring moisture contents varying from 22 to 78% in chopped alfalfa and from 34 to 80% in chopped corn. The Dickey-John was evaluated with chopped alfalfa samples ranging from 20 to 76% moisture content. When chopping forage to store as silage, the moisture content typically ranges from about 35 to 75%, well within the measurement range of the Dickey-John.

Accuracy: FIGURE 2 presents results for the Dickey-John in chopped alfalfa when using the manufacturer's moisture conversion table for green chopped alfalfa. Each moisture content is determined from an average of four readings on the same batch, as recommended by the manufacturer. The best fit line gives average results for 128 samples of chopped alfalfa collected in a variety of fields around Portage la Prairie. Average moisture contents indicated by the Dickey-John varied from accurate readings (at 20% moisture content) to 25% low (at 70% moisture content).

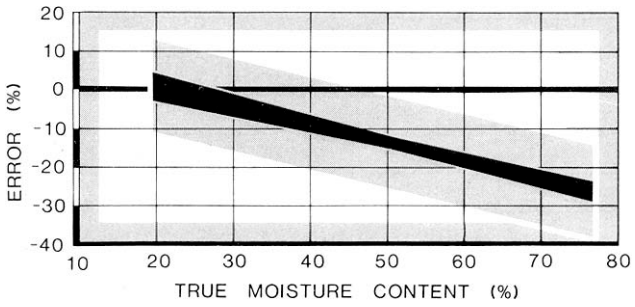

FIGURE 2. Accuracy in Chopped Alfalfa.

FIGURE 3 similarly shows the accuracy of the Dickey-John in chopped corn when using the manufacturer's moisture conversion table for green chopped corn. Average moisture contents indicated by the Dickey-John varied from 5% low (at 40% moisture content) to 6.5% low (at 72% moisture content).

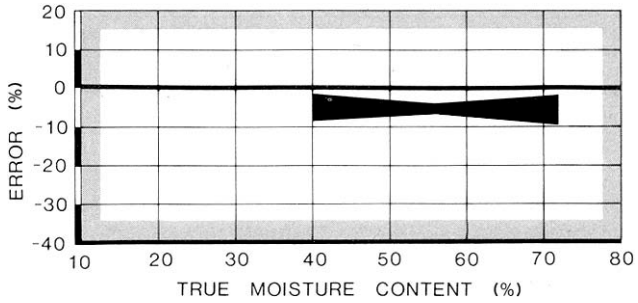

FIGURE 3. Accuracy in Chopped Corn.

An accuracy of 5% is an acceptable level of accuracy for most forage operations. It is recommended that the manufacturer consider providing conversion tables suitable for typical prairie forage crops.

Uncertainty: Uncertainty is indicated by the 95% confidence limits displayed by the width of the line in FIGURES 2 and 3. This uncertainty results from both sample variation and meter repeatability.

The wide, shaded area (scatter) indicated in FIGURE 2 shows the effect sample variation will have on the meter reading when only single measurements from a forage sample are taken. The manufacturer recommends that readings be taken from at least three samples within a batch to reduce uncertainty from sample variation. Averaging four readings in alfalfa reduced this uncertainty from a scatter of ± 13% for single meter readings down to a scatter varying from ±1.1% to ±2.8%. Similarly, in corn, the uncertainty was reduced from a scatter of ±12.5% for single meter readings down to a scatter varying from ±1.1% to ±1% when averaging four readings. This difference in the scatter shows the importance of averaging a number of readings when determining moisture content.

Repeatability: Meter repeatability (APPENDIX II) is the measure of how consistently a meter gives the same reading if the same sample is measured several times. It indicates how subject the measurement method is to both operator error and instrument error. The repeatability of the Dickey-John was good in both alfalfa and corn.

Temperature Compensation: Temperature compensation was provided for within the circuitry of the meter. To receive the corrected temperature reading, the temperature compensator key had to be depressed 30 seconds after the sample loading. The temperature compensator button stuck in the depressed position twice during the test.

Pressure Control: The meter would give a correct reading only if the sample chamber was sufficiently loaded to ensure that the plunger mechanism did not lock in position. The pressure switch was activated through the calibrated spring in the base of the meter when the prescribed force was applied to the plunger. This method of ensuring the proper sample compression was convenient.

Calibration Curves: FIGURES 4 and 5 (APPENDIX II) present PAMI calibration curves for the Dickey-John in alfalfa and corn, respectively. These curves are based on a wide variety of alfalfa and corn crops in the Portage la Prairie area and are fora sample temperature of 20°C at the predetermined sample compression. The confidence belts on these curves indicate expected scatter due to sample variation when the meter reading is based on an average of four measurements on each batch.

Significant errors resulted from using the manufacturer's moisture tables for prairie forage crops. More accurate tables were needed.

OPERATOR MANUAL

The operator manual was easy to read and understand. It contained comprehensive operating instructions, discussed sample. selection procedures and contained moisture tables for several types of forages. As discussed, these tables were not suitable for typical prairie forage crops. As well, no procedure for preparing samples from unchopped material were provided.

APPENDIX I

Make:	Dickey-John
Serial No.:	0165-0836
Electrical Power Requirements:	1 - 9V Battery (NEMA Type 1604)
Overall Dimensions:	
-- depth	195 mm
-- width	200 mm
-- height	3.30 mm
Weight:	1.7 kg
Forage Sample Size:	300 g (@ approx. 60% moisture content)
Principle of Operation:	electrical capacitance

APPENDIX II

(a) *Dickey-John Cafibration Curves derived from PAMI Test Data:* To use the calibration curves, enter the reading obtained from the digital display on the meter into the vertical axis and read true moisture content from the horizontal axis. For example, in corn, a meter reading of '60' corresponds to a true moisture content of 60%.

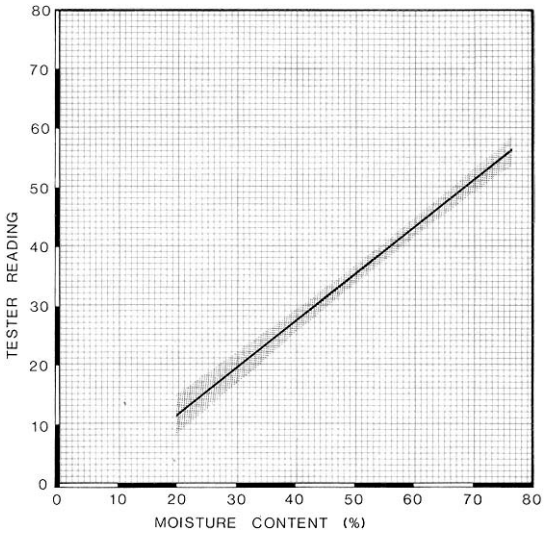

FIGURE 4. PAMI Calibration Curve for Alfalfa.

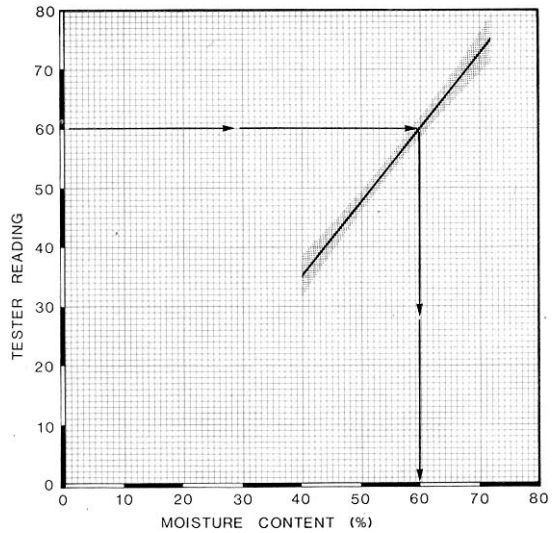

FIGURE 5. PAMI Calibration Curve for Corn.

(b) *Regression Equations:* TABLE 1 presents regression equations for the Dickey-John in corn and alfalfa. In the table,
R = the meter digital display reading;
M = the sample moisture content, percent wet basis, over the ranges specified on FIGURES 4 and 5.

TABLE 1. Regression Equations

CROP	FIGURE NO.	REGRESSION EQUATION	CORRELATION COEFFICIENT
Alfalfa	4	R = 0.78 M - 3.96	0.85
Corn	5	R = 1.25 M - 14.93	0.73

(c) *Meter Repeatability:* To eliminate the effect of sample variation, moisture meter repeatability was determined by relating the coefficient of variation (CV) of the meter to that of the oven dry method. The coefficients of variation were determined by expressing the standard deviation as a percent of the mean for each of the four samples taken from each forage batch. The values, in alfalfa and 4.2% in corn, for the meter; and 2.0% in alfalfa and 2.3% in corn, by the oven method, are the average coefficients of variation for all samples. The equation used to derive the meter repeatability was:

$$\text{Repeatability} = [(\text{CV meter})^2 - (\text{CV oven})^2]^{1/2}$$

Repeatability for the Dickey-John was 4.4% in alfalfa and 3.5% in corn.

APPENDIX III

CONVERSION TABLE:

1 millimetre (mm)	= 0.04 inches (in)
1 kilogram (kg)	= 2.2 pounds mass (lb)

APPENDIX IV

MACHINE RATINGS:

The following rating scale is used in PAMI Evaluation Reports:

(a) excellent	(d) fair
(b) very good	(e) poor
(c) good	(f) unsatisfactory

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