COMPARISON OF ELECTRICAL MOISTURE METERS FOR BALED ALFALFA HAY[1]

W.H. Henson, Jr., G.M. Turner, M. Collins and O.J. Yeoman[2]

INTRODUCTION

A primary concern in producing quality alfalfa hay is moisture measurement. Some precision in moisture measurement is required since hay can be too wet, leading to dry matter and quality loss through mold; it can be too dry, leading to shatter loss during baling, handling and storage.

Moisture measurement in hay can take many forms. One form of subjective (personal judgment) evaluation is brittleness of leaves and stems in the windrow or bale. Typical objective methods consist of electric meters with calibration curves and oven drying.

Several electrical moisture meters have been developed for measuring hay moisture content. These field meters are portable and easy to use, except that they depend on a calibration curve which relates the meter reading to hay moisture content. Moisture measurement assumes considerable importance in marketing and storage of other crops such as grains, soybeans, peanuts, and tobacco. Moisture measurement has developed to a precise degree where the product can be measured under standard conditions of density and moisture, and over narrow moisture content ranges. These conditions can be met at grain elevators and tobacco redriers. However, the typical situation for hay moisture measurement is in the field windrows where density, temperature and moisture can fluctuate over wide ranges.

The objective of the present study was to compare four electrical moisture meters and one relative humidity meter for measuring the moisture content of baled alfalfa hay.

MATERIALS AND METHODS

Four electrical moisture meters were used to measure 10 bales (14" x 18" x 36") of alfalfa hay at moisture contents of 10 to 40% wet basis. The bales were wrapped in large plastic bags to

conserve moisture. The meters were: Froment with flat grid electrodes; Moisture Register Company with two 12-inch probes; Delmhorst with 6-inch probe; and Microwave radiation in the x-band (10 ghz). The relative humidity meter with 12-inch probe operates on the principle of a moisture sensitive element which is mechanically coupled to the meter pointer. The first three instruments are commercially available.

The electrical moisture meters read moisture content indirectly by applying either a direct or alternating current and by measuring the effects of moisture on current flow. The advantage of these meters is that the measurement does not disturb the sample (non-destructive measurement). The direct method involves drying the sample at high temperature greater than 212°C and thus makes the sample useless for further testing (destructive measurement). The relative humidity meter operates on the principle that internal relative humidity of the bale is proportional to hay moisture content.

The Delmhorst meter employed direct current, whereas the other electrical meters employed high frequency alternating current. The Froment and MRC meters operated at approximately 5 mhz, whereas the microwave meter operated at 10,000 mhz. Measurements can be made with the Froment and Microwave with samples wrapped in thin plastic bags since the electrical energy easily penetrates thin layers at these high frequencies.

The hay moisture content was measured with these instruments in a laboratory where conditions were maintained at 70°F and 50% relative humidity. Measurements were made at 9", 18" and 27" along the bale and through the shortest 14-inch dimension. After electrical measurements were completed, the bales were dried in a forced convection dryer; and moisture content was expressed as percent of wet weight according to the equation:

$$\% \text{ Moisture Content (wet basis)} = W_o - W_f)/W_o \text{ X } 100$$

where,

W_o = Weight of sample before drying, and

W_f = Weight of sample after drying.

Eight replications of meter readings were made on each bale with each of the five meters. The accuracy of the meters was judged based on the simple correlation coefficients with hay moisture content.

RESULTS AND DISCUSSION

Meter accuracy was based on measurements which were made in bales of widely varying density and moisture content, such as one would encounter under actual field conditions. Meter accuracy

would be expected to improve for measurements on a single bale where moisture content alone was varied.

A comparison of meter accuracy is shown in Figure 1. Based on how the meter readings correlated with moisture content, the best meter was the Delmhorst.

The meter with the highest correlation with moisture content was the Delmhorst hay meter, a commercial meter with a scale calibrated for hay. The meter with the poorest correlation with hay moisture content was the relative humidity meter.

The meter reading and moisture contents were analyzed by multiple regression. Based on the analysis, the R^2 was 0.81 with a mean of 28% MC (80 observations), and a standard error of estimate of 6.6% MC for the Delmhorst meter, where MC = moisture content.

Instrument precision can be increased by taking several readings on a sample and by computing the average MC. For example, the precision for the Delmhorst meter can be computed by the equation $P^2 = 173/n$. The value of 173 was computed by $t^2 \times s^2$, where t = 1.99 (Students' t for 80 observation and the 95% confidence level) and s = 6.6% MC (standard error). Here, p = precision in percent MC and n = number of readings on a sample. Thus, if one wants to measure with a precision of $\pm$ 3% MC, then the required number of readings is 173/(3 x 3) = 19.
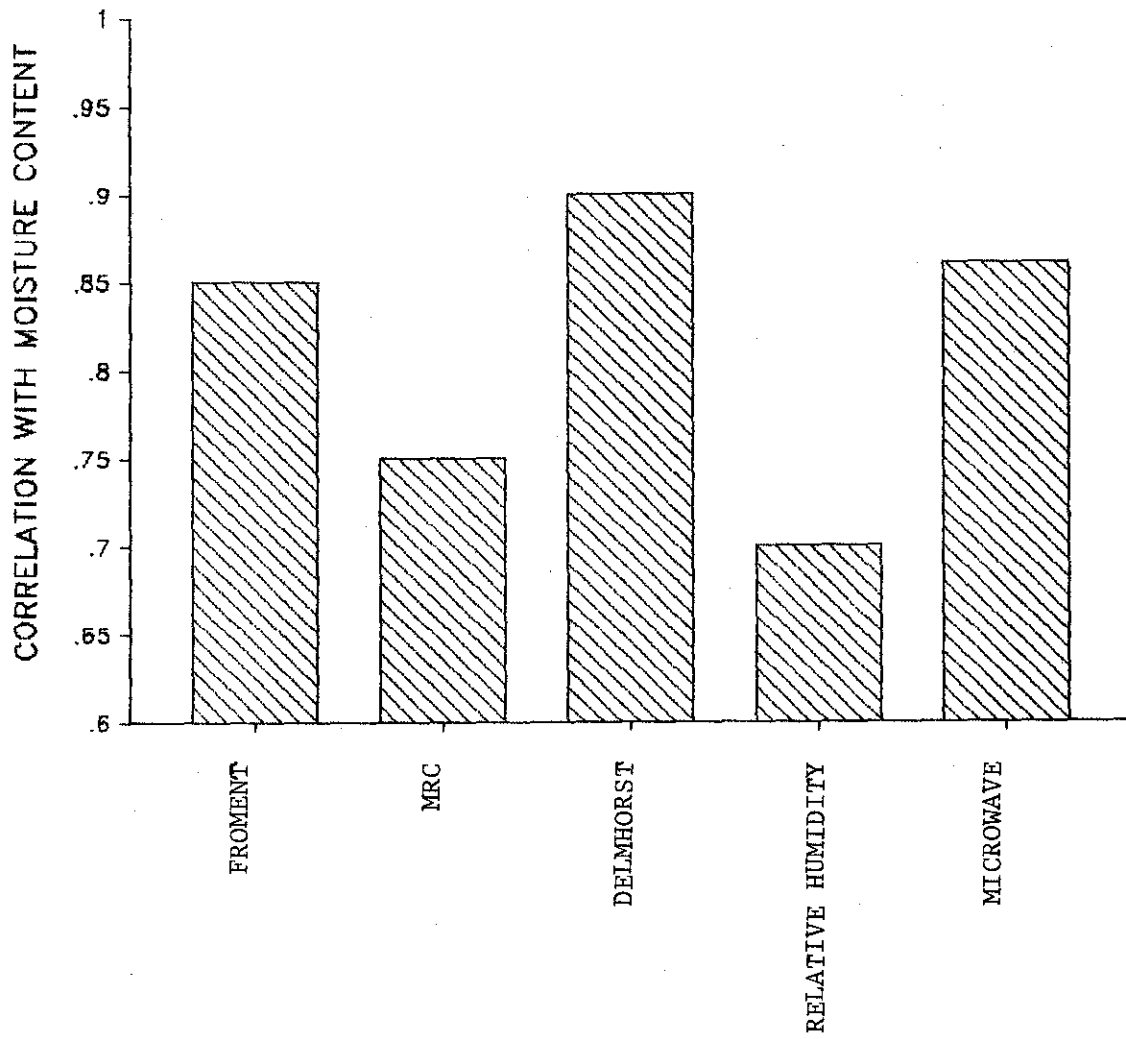
Figure 1: Comparison of Meter Accuracy.