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Moisture Meter Performance II. Soybeans

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Abstract

Three trade-type moisture meters, Steinlite SS250, Motomco 919 and Dickey-john GACII*, were compared with the USDA two-stage air-oven method on 204 samples of 1983 and 1984 crop soybeans. The GACII and Motomco meters read within 0.2 percentage points of the oven, whereas SS250 read 0.4 to 0.6 points higher than the oven. Variance of the meters relative to the oven held constant over the moisture range 8% to 17% (wet basis). The standard deviation of a meter reading relative to the oven was 0.3 percentage points, about half that of corn in the same moisture range.

Disciplines

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Comments

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Technical Notes:

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ABSTRACT

THREE trade-type moisture meters, Steinlite SS250, Motomco 919 and Dickey-john GACII*, were compared with the USDA two-stage air-oven method on 204 samples of 1983 and 1984 crop soybeans. The GACII and Motomco meters read within 0.2 percentage points of the oven, whereas SS250 read 0.4 to 0.6 points higher than the oven. Variance of the meters relative to the oven held constant over the moisture range 8% to 17% (wet basis). The standard deviation of a meter reading relative to the oven was 0.3 percentage points, about half that of corn in the same moisture range.

INTRODUCTION

The economic cost for one percentage point of moisture in soybeans (over or under 13.0%) is 1.5 to 2.0% of market value. Yet the extensive literature on grain moisture measurement contains information on soybean electrical properties (ASAE 1983) but not discussion of moisture meter performance with soybeans. Previous meter-performance studies involved corn (Hurburgh et al., 1985; Paulsen et al., 1983). Many of the factors that complicate corn moisture measurement—shape, surface texture, kernel size, large moisture range—are not as variable in soybeans. A review of the factors and theoretical concepts of dielectric properties was published by Nelson (1981). Because moisture meters only approximate the dielectric-constant to moisture relationship, the smaller range of moisture contents, 8% to 18%, as compared with 8% to 38% for corn, should produce greater accuracy and precision with soybeans. Hurburgh et al. (1985) demonstrated that both accuracy and precision are functions of moisture content, for corn.

The reference basis for soybean moisture measurement is two-stage air-oven method established by the United States Department of Agriculture in 1942 (USDA, 1980a, 1976). Calibrations for electronic meters are established by meter manufacturers or by the Federal Grain Inspection Service (FGIS) for Motomco meters.

A 16-sample Iowa State University study indicated (a) that meter calibrations were in error with respect to the oven and (b) that random error in soybean testing was about half the random error in corn testing (Grama et al., 1982). A more complete investigation was required to confirm these findings and to extend the moisture-meter performance analysis to soybeans.

OBJECTIVES

1. Determine the accuracy of current soybean moisture calibrations.
2. Quantify variance in soybean moisture testing.

MATERIALS AND METHODS

The three most popular moisture meters in the Iowa grain trade are the Steinlite SS250, the Dickey-john GACII, and the Motomco 919 (Hurburgh et al., 1985). Table 1 gives their specifications relative to soybean moisture tests.

Our laboratory units, the same units used in the corn study (Hurburgh et al., 1985), were verified by comparison with a factory "master" unit to be representative of their particular models.

The two-stage air-oven method used by FGIS (USDA, 1976) was the reference method for the meters. As a check on our technique, five samples were sent to the Federal Grain Inspection Service, Standardization Division. On these samples, we averaged 11.39% oven moisture and FGIS 11.32%.

Soybeans from two crop years, 1983 and 1984, were tested. The 97 samples of 1983 soybeans and 107 samples of 1984 soybeans were collected at 10 elevators across Iowa, one elevator each in Illinois and Ohio, and 10 elevators in Minnesota. All samples were collected during harvest season as the soybeans were delivered to the elevator.

The samples were collected from deliveries received on a single day, bagged, and stored at 2°C until tested. The samples were warmed to room temperature before

TABLE 1. MOISTURE METERS AND THEIR SOYBEAN CALIBRATIONS

Calibration information				
Meter model	Method (effective date)	Applicable moisture range, percent	Sample size, g	Temperature correction
Steinlite SS250	Soybean module (1/77)	9.0 -18.0	250	Automatic
Motomco 919*	Chart S-1-B Chart S-2-A (9/77)	8.83-18.27 18.27-21.61	250 250	Manual Manual
Dickey-john GACII	K1-K9 values (3/80)	7.0 -21.0	Internal weighing	Automatic

*Calibrations performed by Federal Grain Inspection Service.

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opening. Samples were processed in the following manner:

1. The test weight, in pounds per bushel, was determined by the FGIS method (USDA, 1980b).
2. Splits and foreign material were measured (USDA, 1980b) and removed.
3. Approximately 40 g were removed for the first stage of the oven test, weighed to ± 1 mg and set aside in equilibrate.
4. The sample was tested three times each in the Motomco, SS250, and GACII meters.
5. After two days of equilibration, triplicate ground subsamples were weighed to ± 1 mg and placed in the oven.

The data were categorized by year and by increments of 1% moisture within years. In each increment, the average meter error (meter minus oven), its variance, the average variance among meter readings on a grain sample, and the average variance among oven replicates were calculated.

For each brand and year, meter error was plotted against oven moisture content. For all brands and years pooled, the incremental meter-to-oven variances, within-meter variances and within-oven variances were regressed against oven moisture. This procedure utilized the variance-component model developed by Hurburgh et al. (1985) and modified to include year-to-year changes in grain electrical properties (Hurburgh et al, 1986).

$$V_{mo} = V_y + V_{ss} + \frac{V_m}{n_m} + \frac{V_o}{n_o} \qquad \text{[1]}$$

where:

V_{mo} = meter-to-oven variance within a crop year
V_y = variance among crop years
V_{ss} = sample-to-sample variance representing delectric variations across samples
V_m = within-meter variance
V_o = within-oven variance
n_m = number of meter tests per sample (=3)
n_o = number of oven tests per sample (=3)

The square root of each component yields the standard deviation, in points of moisture, associated with the component.

RESULTS AND DISCUSSION

Meter errors, meter moisture (M_m) minus moisture (M_o), are shown in Fig. 1. Within increments, mean errors for 1983 and 1984 were averaged arithmetically without regard to sample numbers. In no increment was there a statistically significant difference between 1983 and 1984 data. Data points shaded in boxes are statistically equal ($P<0.05$).

The variance-component model revealed no relationship between any variance component and oven moisture. This differed from the corn study in which V_{mo}, V_m, and V_{ss} were quadratic functions of moisture content (Hurburgh et al. 1985).

Since the 2 years variance data were also not statistically different, V_y was eliminated from equation [1]. Variance component values, their respective shares of total variance and a comparison to corn moisture testing are given in Table 2. The total variance, V_{mo}, is just over five times greater for corn than soybeans.

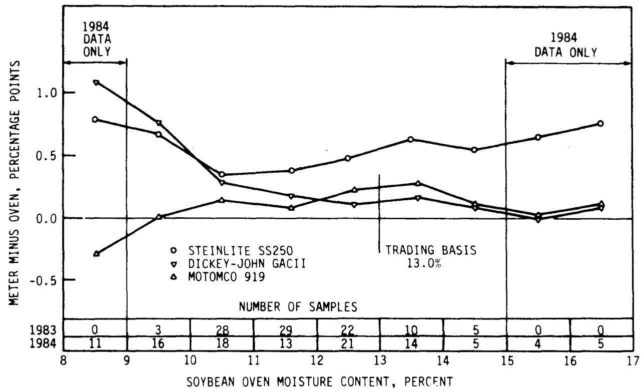

Fig. 1—Accuracy of three trade-type moisture meters in soybeans. *Shaded points not statistically different (P<0.05) from each other.

Because variances are squared standard deviations, meters will have actual variability 2 to 2.5 times as large in corn as in soybeans. The overall standard deviation of a meter-to-oven comparison in soybeans was 0.27 percentage point.

CONCLUSIONS

1. At the moistures common in trade, 10%-16%, the Motomco 919, and GACII moisture meters read within 0.2 percentage points of the oven. The SS250 meter read 0.4 to 0.6 points higher than the oven in this moisture range.
2. Variance remained constant between 8% and 17% moisture. The meters were less than half as variable in soybeans as in corn of the same moisture content. A single soybean moisture test had an estimated standard deviation with respect to the oven of 0.27 percentage points.
3. Dielectric variations across samples creates 89.9% of total variance, meter precision 3.3%, and oven precision 6.8%.

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TABLE 2. VARIABILITY IN MOISTURE TESTING OF CORN AND SOYBEANS*

Variance component	Variance value†		Share of total variance,%†	
	Corn	Soybeans	Corn	Soybeans
Sample, V_{ss}	0.3469	0.0652	91.6	89.9
Meter, V_m	0.0220	0.0023	5.8	3.3
Oven, $V_o/3$	0.0098	0.0050	2.6	6.8
Total, V_{mo}	0.3789	0.0725	100.0	100.0

*Corn data at 13.0% moisture, after Hurburgh et al. (1985).
†Assuming one meter test and three oven tests per sample.

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