NATIONAL FOOD AUTHORITY
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Validation of Weight Loss Measurements

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I. BASIC INFORMATION

1. Research Title	:	**Validation of Weight Loss Measurements**
2. Researchers	:	**Engr. Tessie Q. Ramirez** **Lita B. Bernal**
3. Implementing Agency	:	**National Food Authority**
4. Research Sites	:	**NFA-Cabanatuan City**
5. Funding Agency	:	**National Food Authority**
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7. Development Zone	:	**Storage Loss Procedures**
8. Commodity	:	**Palay**

Validation of Weight Loss Measurements[1]

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ABSTRACT

The weight-volume method and the thousand grain mass (TGM) are two procedures for weight loss determination for paddy. These were tested and compared with the results of the total weight loss assessment procedure.

The weight loss derived from the weight-volume method showed significant relationship with storage period. But when compared with the weight loss results of the total weight loss assessment procedure, the weight-volume method results came out to be significantly different.

The weight-volume method could be a good tool in measuring or predicting the estimated loss of stored palay. This method includes losses brought about by all possible nature-caused factors. Refinement of the procedure is therefore necessary for it to become acceptable.

On the other hand, the weight loss generated from the thousand grain mass procedure yielded insignificant relationship with storage period. Thus, it was no longer compared with the results of the total weight loss assessment. The TGM, therefore, cannot be used for weight loss determination of paddy.

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[1] Study conducted by the Technical Research Division, Technology Resource Development Department, National Food Authority, Quezon City.

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INTRODUCTION

The perennial problem of the National Food Authority is weight loss of cereal stocks in its warehouses. Loss assessment had been done to determine weight losses of stored paddy grains. The procedure of weight loss assessment involved weighing of stocks which incurred huge expenditures. Warehouse transaction receipts and issues of stocks could not be used to come up of specific data loss since the stocks and recording were not under the control and monitoring of researchers.

Adams and Schulten (1976) presented simpler ways of determining storage loss through Standard Volume/Weight Method. The procedure primarily involves moisture and weight determination of grains at a given standard volume. Above all, the procedure is inexpensive.

Likewise, Proctor and Rowley (1983) devised the Thousand Grain Mass (TGM) in determining weight loss of grains. The procedure is also simple and inexpensive. It also involves moisture and weight determination and counting of weighed grains.

Both procedures do not involve large amount of money and can be both adopted as part of warehouse operations to predict weight losses in case these procedures are found effective.

REVIEW OF LITERATURE

The rice weevil consumes rice when living in the kernel. If the kernel is weighed before and after it is bored, it will have lost weight. The rat and birds also consume part of the stored grain. If the stocks are weighed before and after storage, losses will be recorded. This lost in weight is the removed food grain from the direct human food chain which is the basic source of energy of most people in developing countries.

On the other hand, loss of weight due to moisture may not be a loss of food grain. However, in the accounting system of the NFA, it is considered a weight loss which equivalent cost must be determined. Likewise, pilferage must not be considered a loss. It is a transfer of ownership, and is punishable.

Losses in storage are caused by the activities of various macro- and microorganisms made possible by man's failure to understand and follow proper storage principles and practices. Losses caused by mite and insect infestation and by the depredations of large animals such as rats, mice and birds are obvious. Thus, the means of control of these pests are generally known and supposed to be practiced. Losses caused by the activities of microorganisms are less understood and often unrecognized.

This study, however, does not focus on the factors of losses. It merely attempts to measure the total loss of stored grains.

OBJECTIVE

The study aimed to validate the Standard Volume/Weight method designed by Adams and Schulten (1976) and the Thousand Grain Mass method designed by Proctor and Rowley (1983) in determining weight loss of cereals with an end view of arriving at a simpler and acceptable procedure of predicting weight loss for adoption into the NFA operations.

METHODOLOGY

Three piles of paddy containing about 5,000 bags per pile were used for this study. These were stored at warehouse 7 at the NFA Complex in Cabanatuan City. Three loss measurement methods were used: the weight-volume method, the thousand grain mass, and the total weight loss assessment.

A. Assessment of Loss Measurement Methods

1. Standard Weight/Volume Method

1.1 Baseline Determination

A baseline was necessary to be established as basis for succeeding measurements since the weight-to-volume method was based on varying weights for different levels of loss. The baseline was in the form of curve covering several moisture conditions possible for paddy. Paddy volume changed at varying moisture contents. The baseline curve was inevitable because it served as reference point in comparing losses incurred during storage.

About ten kilograms of paddy were obtained from the three experimental piles. These were thoroughly mixed until sub-samples for moisture content determination were obtained. The paddy moisture was recorded at 13.2%

Using the weight per liter tester, the weight of a standard volume (1000 cc) of the well-mixed 10-kg paddy sample was immediately obtained and recorded.

After taking the weight of the one-liter liter palay, this was sun-dried, tempered, and the moisture content and weight per liter were again determined. Sun drying of the palay was again immediately done to obtain a lower MC. The drying, moisture determination, and weight per liter monitoring were continuously done until the paddy was dried to almost 8% moisture. Sund rying was done up to a moisture level of about 9%. Drying up of the paddy to less than 9% was unsuccessful, thus the air oven was used to dry the grains dopwn to about 8% moisture.

The palay moisture and its corresponding weight per 1000 cc were plotted to come up with a baseline which was used as reference in loss measurement. The weights in the baseline were referred to as W_i while the moisture contents were referred to as MC_i.

1.2 Loss Measurement

For the first three months, samples were withdrawn weekly and separately from each pile. Analysis of the samples were on per pile basis. A well-mixed sample was analyzed of its moisture content and weight using the weight per liter tester. The weight was termed W_f. while the moisture was MC_f.

Using the baseline figure, a vertical line was drawn from the moisture content axis (X axis) equivalent to the MC_f. Where the MC_f vertical line intersected on the baseline, a horizontal line was drawn going to the weight per liter axis (Y-axis). The datum obtained was W_f. This procedure was subsequently used every monitoring time to determine the estimated change in weight of the stored palay. The percentage weight loss was calculated using the formula:

$$\%\ \text{Weight Loss (Wt.-Vol.)} = \frac{W_i - W_f}{W_i} \times 100$$

Where % Weight Loss (Wt-Vol) is the cumulative weight loss using the weight-volume method

W_i is the weight found on the baseline

W_f is the weight at a given monitoring time

2. Thousand Grain Mass

Using the same paddy samples utilized in the moisture content and volume-weight determination, grains were counted up to 1000 for several trials at the start of the experiment. Counting was also on per pile basis. The counted paddy grains were weighed and recorded as Thousand Grain Mass (TGM).

Subsequent readings of TGM were done along with the volume-weight determination.

The weight loss was determined using the following formula:

$$\%\ \text{Weight Loss (TGM)} = \frac{W_i - W_f}{W_i} \times 100$$

where W_i = initial weight of 1000 grains (taken at the start of the experiment)

W_f = weight at a given time

3. Total Weight Loss Assessment

The weights of the three experimental piles were recorded at the start of piling. Subsequent re-weighing every three months was done to determine the actual weight loss incurred by the palay while in storage. This procedure was considered as control among all the methods presented.

The total weight loss was calculated as follows:

$$\% \text{ Total Weight Loss} = \frac{W_i - W_f}{W_i} \times 100$$

Where % Total Weight Loss = cumulative weight loss obtained by quarterly weighing of the palay stocks

W_i = initial weight of the experimental palay stocks

W_f = weight of the experimental palay stocks at a given monitoring period.

The weight loss results from the volume-weight method, thousand grain mass, and Total Weight Loss assessment were compared.

DISCUSSION OF RESULTS

1. Volume-Weight Method

1.1 Baseline

Figure 1 shows the baseline which represents the true condition of the paddy without any weight loss except moisture. This line is being used as reference in determining weight loss of stored paddy. The baseline shows a linear downward trend as moisture increases. This trend indicates that the weight of palay at constant volume is heavier when dried. This result agrees with the trend of the sample baseline figure of unidentified cereal given by Adams and Schulten (1976).
At a fixed volume, the drier paddy grains are more heavy compared to the grains with higher moisture content. This means that more grains are contained in the fixed volume container when they are drier. Or in a smaller scale, a single dry grain occupies lesser volume than a wet grain.

The derived baseline appears to be a good reference because the data points are not scattered over a wide area.

1.2 Loss Measurement

The average moisture content behavior of the paddy is given in Figure 2. It shows a downward logarithmic trend of moisture content indicating that the grains dry up during storage. Although moisture loss is not a food loss, still, it is considered a quantitative loss in NFA operation which, if not properly accounted, may become a problem on the part of the accountable officer.

Likewise, the weight of the paddy grains decreases at prolonged storage as shown in Figure 3. One of the factors of weight loss is moisture loss. Other cause of weight loss is the loss of a portion of the grain which may be due to insect or rodent consumption and grain respiration (Houston, 1972).

The weight of the paddy contained in a fixed volume container is inversely proportional with time or storage period. Conversely, the equivalent weight lost is directly proportional with storage period as shown in Figure 5. The trend of weight of paddy lost as measured through the weight-volume method is logarithmic. The positive slope (the coefficient of the variable X which is +1.19 as shown in Table 1) also proves that the weight loss is directly proportional with storage period.

The regression equation is considered accurate based from its correlation coefficient, r^2, of 0.896. At 95% confidence level, the weight loss from the weight-volume method was found out to have a significant relationship with time having a probability, P, of less than 0.05% (Table 1).

2. Thousand Grain Mass

Figure 4 shows the scatter plot of TGM of paddy while in storage. The scatter plot is widely spread, indicating no trend for TGM curve. The scatter plot apparently indicates that the grains constantly gain and lose weight. The grains may occasionally gain weight due to moisture absorption when the humidity becomes high but, most of the time, it frequently loses some of its weight until it is in equilibrium to its relatively low-humidity environment. But using the TGM, it appears that the grains constantly gain and lose weight which is not expected to happen. There are definitely other contributory factors, aside from moisture absorption/desorption, why the constant gain and loss behavior happens as the TGM scatter plot suggests. One major factor is the naturally occurring variability in individual grain weights. This factor of error can hardly be minimized because of the very small quantity of samples analyzed, being only 1000 grains per trial. Another on going TRDD research project, "Performance Evaluation of Bulk Storage Facilities in Isabela," conducted by Sugue et al. showed similar erratic pattern of TGM behavior in its initial results.

Still the weight loss of paddy measured through TGM, was tested to confirm the result of the scatter plot. The weight loss pattern is shown in Figure 5. However, the

r^2 is very low, meaning the derived relationship is not a good predictor for weight loss. The probability P is also higher than 0.05% confidence level (Table 1), hence the weight loss has no relationship with storage period. TGM is, therefore, not a good tool to measure the weight loss of paddy.

3. Total Weight Loss Assessment

The actual total weight loss of the paddy grains taken from weighing of the whole three piles is also shown in Figure 5. The graph shows that there is a direct relationship with time. Its trend is also logarithmic with r^2 of 0.944. The probability P is also much lower than 0.05% (Table 1), hence weight loss has significant relationship with storage period. The equation of the line is also shown in Table 1.

B. Comparison of Weight Loss Measurement Methods

Referring to Figure 5, the weight loss results from the volume-weight method has similar logarithmic pattern with total weight loss assessment results. However, their scatter plots in Figure 5 further show that the weight loss derived from the weight-volume method is quite higher than those derived from the total weight loss assessment.

The weight loss data were then subjected to further test to compare both weight loss measurement procedures. Table 2 shows the comparison of results: that total weight loss method is significantly different from weight-volume method.

If the scatter plots are to be scrutinized again, it can be observed that the considerable increase in weight loss of palay using the weight volume method, as compared to the total weight loss assessment, started almost after about 60 days. It is reasonably probable that the contributory factor to the sudden increase in weight loss as measured by the weight-volume method are the mothballs or lumps of grain webbed together by insects.

Mothballs usually form in stored palay after sometime in storage, when pests and/or insects thrive and proliferate in the stocks. The mothballs are not closely knitted well thereby forming loose lumps. If the mothballs become part of the one-liter sample for weight per liter testing, then the resulting weight may be low because the mothballs that are loosely knitted occupy a larger space in the one-liter volume.

The TGM is no longer compared with the two methods because it has already been found out to have no significant relationship with time.

CONCLUSION AND RECOMMENDATION

There still has no loss measurement method that can surpass the total weight loss assessment method. The weight-volume method and the thousand grain mass may need some more refinement in order to come up with loss assessment which can be adopted for storage operations.

The weight-volume method could have been a good procedure in determining the weight loss of stored paddy because all natural or biological losses (caused by respiration) and insect and pest consumption can be recorded with this procedure. Unfortunately, the method has shown larger amount of loss compared to total weight loss assessment. Mothballs or lumps of loosely webbed grains occupying larger than the usual space in the container may have caused the discrepancy. Thus, further refinement of the procedure may be needed.

In refining the weight-volume method, the primary consideration now is to remove mothballs before testing the palay samples. It is tempting to recommend that the samples be cleaned prior to testing. However, there is a point of contention in the cleaning of samples prior to testing as far as NFA operations are concerned. If cleaned, then the sample would not become a representative to the whole stock. Thus, all angles of possible sources of error must be determined and studied. When perfected, the weight loss, caused by unavoidable reasons, of a given stock of paddy can be predicted. If perfected, it is also highly probable that the weight-volume method may be comparable to the total weight loss assessment method. The scatter plots of both methods so indicate.

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Houston, D. F. 1972. RICE: Chemistry and Technology. AACC. St. Paul, Minnesota

Proctor, D. L. and J. O. Rowley. ND. The Thousand Grain Mass (TGM) A Basis for Better Assessment of Weight Losses in Stored Grain. Unpublished report.

Figure 1. Baseline

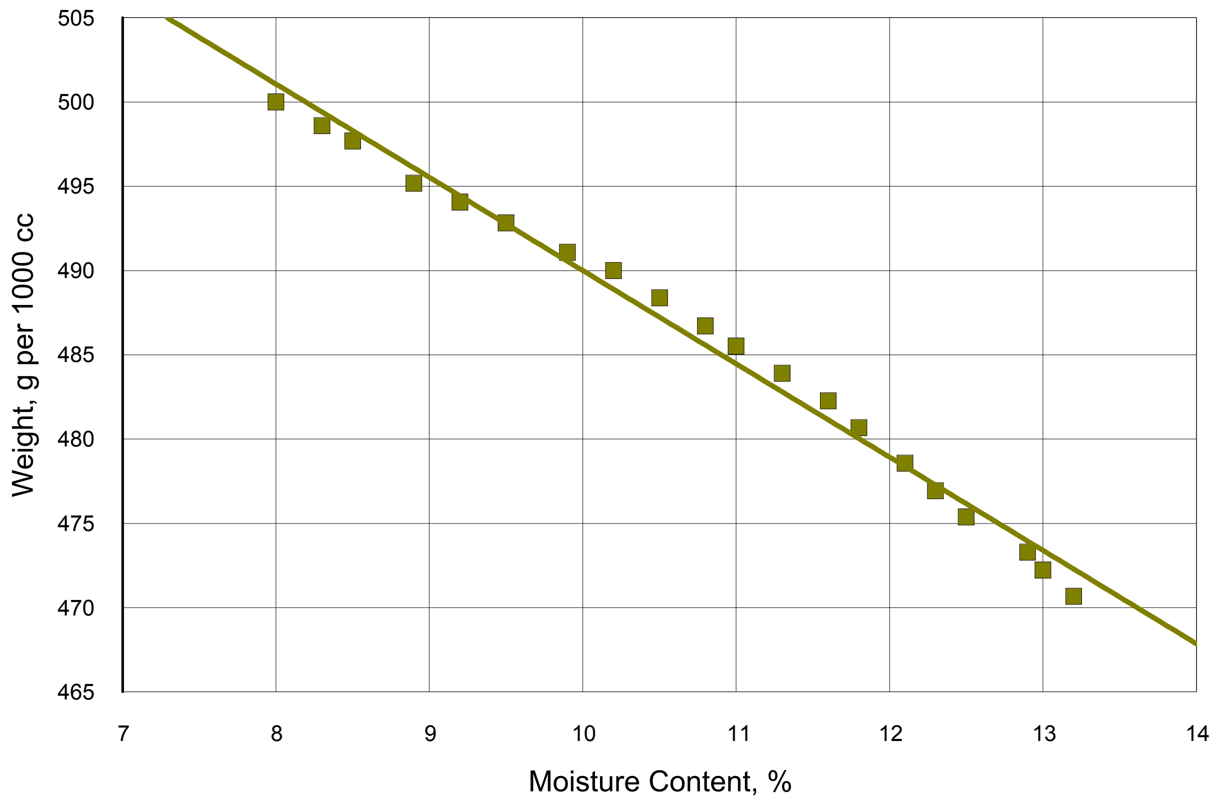

Figure 2. % Moisture Content of Stored Paddy

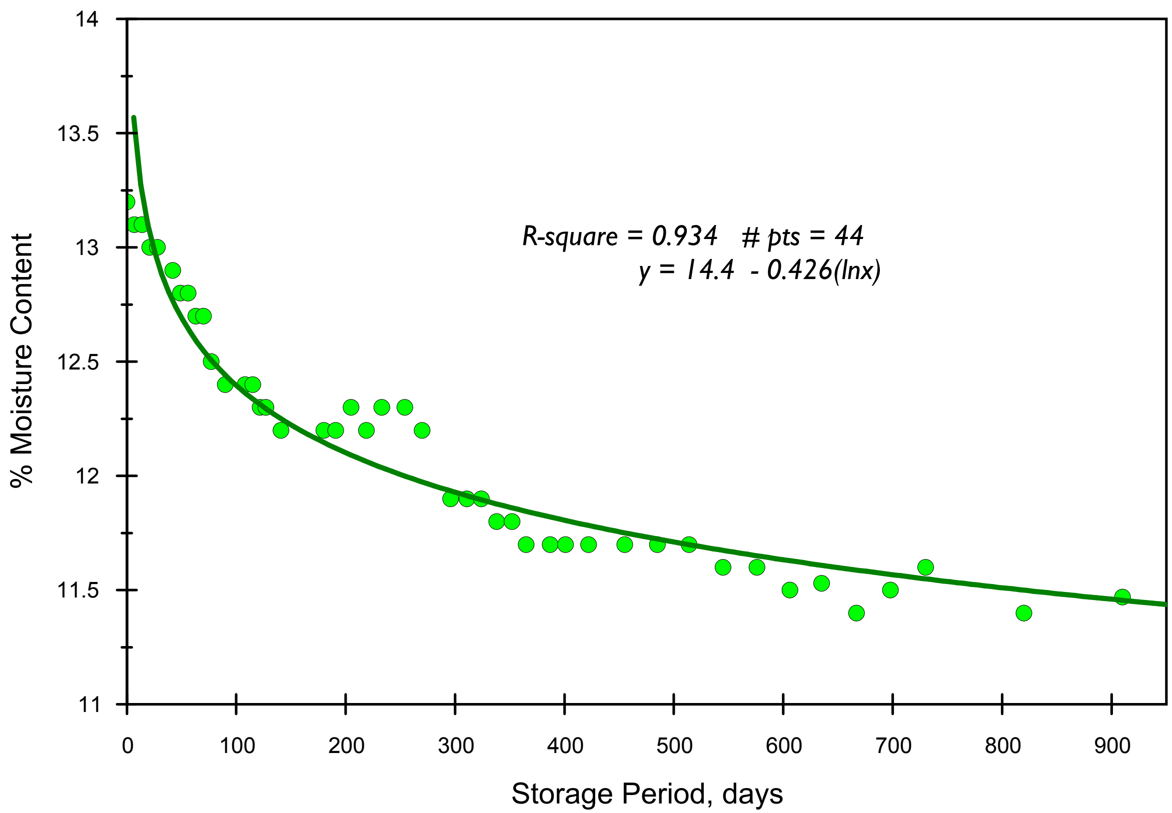

Figure 3. Weight Changes of Stored Paddy

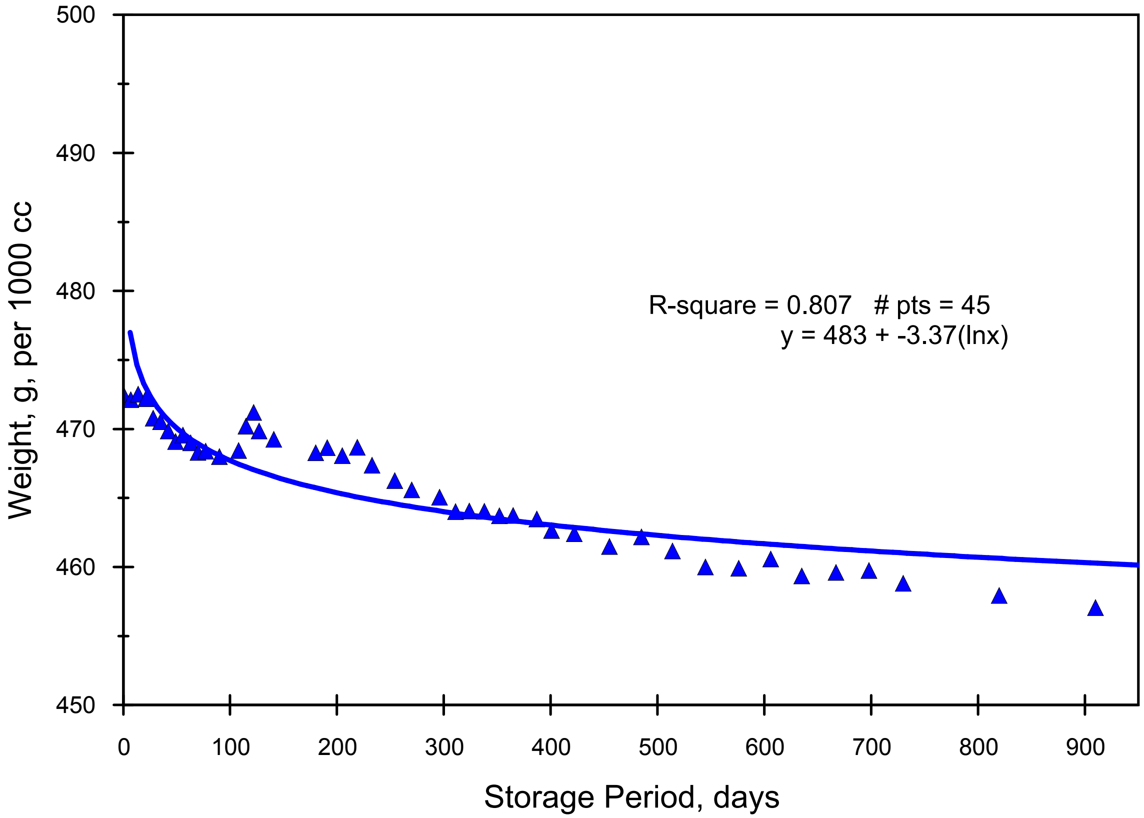

Figure 4. Thousand Grain Mass of Stored Paddy

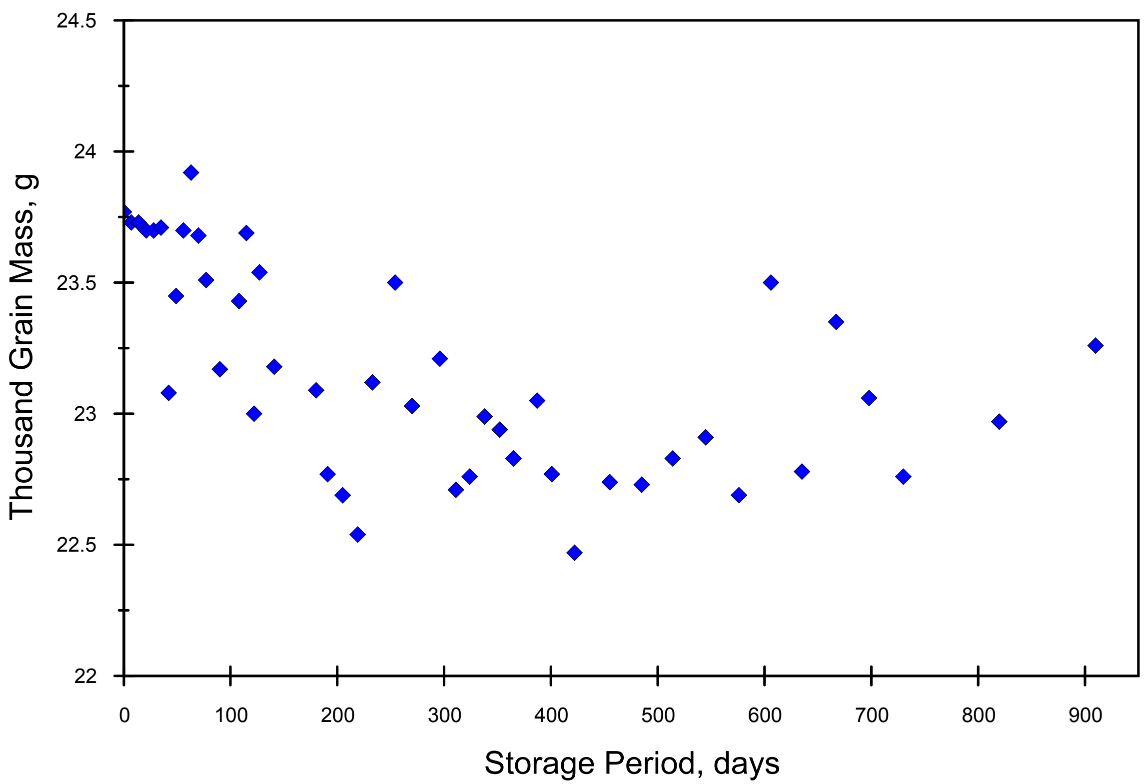

Figure 5. Comparison of Weight Loss Measurements