DETERMINING CAPACITY AND OBSERVING EFFECTS OF STORAGE ON SILAGE IN LARGE DIAMETER TALL SILOS

AN AE 811 SPECIAL PROBLEM

MICHIGAN STATE UNIVERSITY
JOHN WILLIAM COMSTOCK

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By

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ABSTRACT

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by JOHN W. COMSTOCK

It is important from the standpoint of livestock management to know the quantity of silage that can be stored in various size silos. Several researchers have studied the problem of silo capacity but none where silos exceeding 40 feet of height were used.

The primary purpose of this study is to determine the tonnage of corn silage at a given moisture content that can be stored in large diameter tall silos. This includes determinations of weight, volume and density of silage.

Since tonnage alone does not give a complete picture of the quantity of feed stored some analysis of the silage must be made. Therefore, sampling is required whereby the composition can be determined. Thus, a secondary purpose of this experiment is to investigate the change in composition of fresh cut corn and cured corn silage.

Approved Robert L. Maddox
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Approved Carl W. Hall
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REVIEW OF LITERATURE

A review of literature reveals that no scientific investigation of silo capacities in large diameter silos over forty feet high have been published.

Densities and tonnages have been estimated by extrapolation of curves from other investigations (2) (4). Though this method seems logical, at best it can only provide estimates of total tonnages and weight of dry matter (6).

Large diameter tall silos, such as the 30' by 70' sizes used in this experiment, present problems in methods of gathering accurate data due to the huge quantities of material to be handled. Some procedures and techniques were used as suggested by a committee assigned the responsibility in 1956 from the Beltsville Station (1).

It has long been known that considerable losses occur in the preservation of silages in storage. This fact has been observed by several researchers (6) (7) (9). An effort was made in this experiment to determine the amount of loss by analysis of silage samples during the feeding period. Chemical composition and digestibility of cured silage was compared with fresh chopped corn similar to work done by C. F. Huffman and C. W. Duncan (8).

Several density measurements were made to observe silage stored to heights of 68 feet. The layer method was used similar to work by Otis and Pomroy (3) in silos not exceeding 40 feet.

Problems and conditions similar to those experienced during this experiment are discussed in a paper prepared for presentation before the Inter-European Symposium held in Sweden in 1962 (10).

From the data given by these workers and the results of this experiment it becomes obvious that additional study is needed to produce a scientifically accurate method of measuring the quantity and quality of silage in a given structure.

LOCATION OF EXPERIMENT

The farm of Kitty Kurtis, Inc. near Tecumseh, managed by William K. Brown, was selected for the experiment.

Approximately 1000 head of cattle are fed out annually here in paved lots with fenceline feedbunks. The cattle are predominately calves arriving in the fall, fed to approximately 1000 pounds, and marketed in June, July and August.

The feed storage and processing is accomplished in a central feeding system consisting of two 30' x 70' and two 20' x 70' cement stave silos. An overhead bin, a scales and the attendant conveyors make the center adequate for efficient and accurate feed preparation.

A typical feeding operation begins by placement of an automatic unloading wagon on the scale and weighing in the required amount of corn silage. (These quantities of silage were diligently recorded to determine the total weight of silage removed.) High moisture shelled corn and protein supplements are added to the silage at a rate to provide one percent of body weight in grain and protein supplement per day.

The cattle are divided into four lots of approximately 250 head each to provide for better observation and various feeding experiments. An excellent opportunity for experimental work was afforded through a well designed cattle handling facility which included a large scale. The removal of the superstructure from

the scale provided the weighing facility, which was conveniently located to the silos, for the filling operation.

The feed center with the two 30' x 70' silos in the background is shown in the picture below.

METHOD OF INVESTIGATION

An attempt to weigh corn silage in one of the Brown 30' x 70' silos was made in 1960. However, certain difficulties at the outset made it necessary to estimate the first 66 loads.

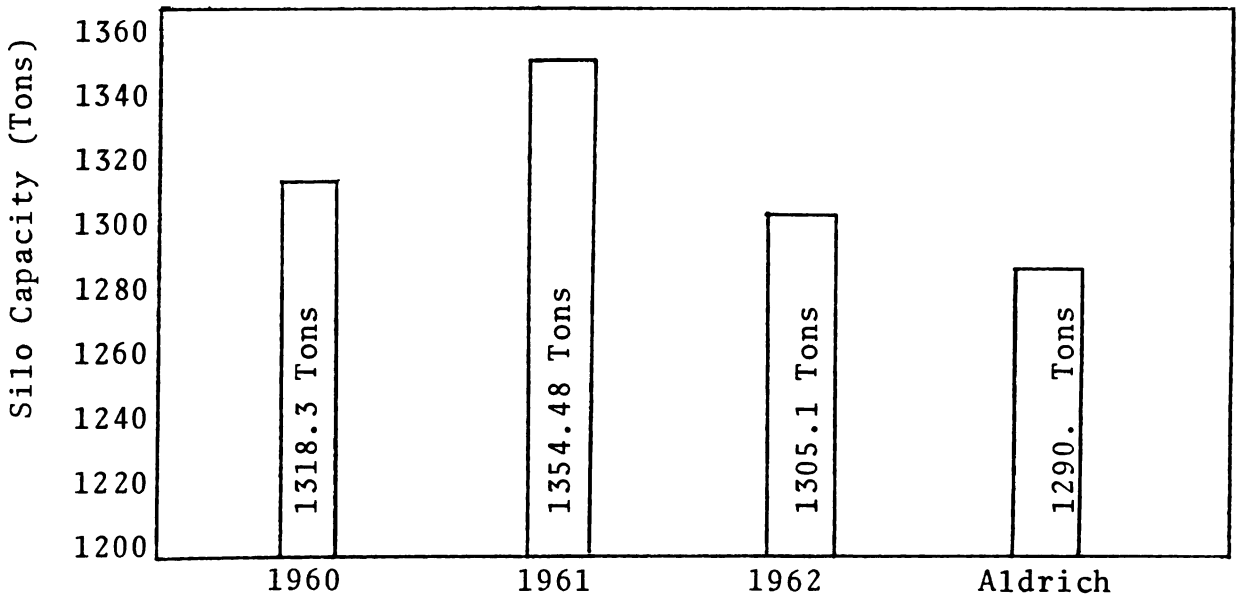
Total tonnage, assuming the first 66 loads were average, was 1318.3 that year with no moisture information available. This experience prompted more elaborate preparation for the 1961 silo filling experiment.

The same 30' x 70' silo was again filled in 1961. 383 loads of fresh chopped corn from fields yielding approximately 100 bushels of shelled corn per acre were required to fill the silo. Each wagon was weighed empty periodically to maintain an accurate tare for determining the net weight of silage. Each loaded wagon was weighed before unloading at the blower. The average net load weight was 7,060 pounds for a total weight of 2,708,970 pounds or 1354.485 tons required to fill the silo. The filling rate was approximately 200 tons per day. Total elapsed time from beginning to final filling was nine days. A silage distributor was used throughout the filling operation.

In 1962 the same 30' x 70' silo and an additional one were filled under experimental procedure where all material was weighed. One silo was filled with conventional full stalk corn while the other was filled with center cut, or corn topped and cut about 26 inches above the ground.

The silo filled with full stalk silage held 1305.1 tons or 49 tons less than the same silo in 1961. This difference can be accounted for partially by the fact that the moisture content was 1.53 percent higher in 1961 than in 1962. Figure 1 compares weights for the three years with extrapolated weights by Aldrich.[2]

Figure 1



Comparison of filling weights of three 30' x 70' silos with extrapolated figures by Aldrich.[2]

1. Average moisture content of silage:

    1960 - not available
    1961 - 70.63%
    1962 - 66.70%
 Aldrich - 70.00%

2. Capacities as percent of Aldrich figures:

    1960 - 102.19%
    1961 - 104.99%
    1962 - 101.19%

The silo filled with center cut corn weighed in 1333.7 tons of 66.7 percent moisture material.

These experiences weighing chopped corn into silos quickly indicate the possibilities for variance. The 1960 work was inconclusive without moisture data and left no opportunity to determine losses during the storage period.

Consequently, in 1961 thorough preparations to sample the chopped corn both in and out of the silo were made.

METHOD OF SAMPLING AND RECORDING DATA

At the beginning of the silo filling operation accurate weights of the four automatic unloading wagons were recorded. Periodically thereafter empty weights were obtained to maintain accurate net weights. Load weights were recorded in a conventional data book kept at the scale which was located approximately fifty feet from the silo.

Samples of the fresh cut corn were taken from, on the average, one in every eighteen loads by the grab method as the wagon unloaded. These samples amounted to about four quarts and were placed into airtight plastic bags immediately. Each day's samples were placed in a freezer to preserve them until the filling was completed at which time they were delivered to the University laboratory.

The samples were then analyzed for ash, crude fiber, ether extract, water, protein and nitrogen free extract. The results of these tests are recorded in Table I on the following page.

Table I. Fresh Chopped Corn for Silage
(From Wm. Brown Farm, Tecumseh, Michigan)
September 1961

Sampling Data					% Expressed on As-received Basis					
Date	Time	Load	Field	No.	Ash	Crude Fiber	Ether Extract	H_2O	Protein	N-Free Extract
9-13	1830	3	1	1	1.59	6.69	.87	68.85	2.47	19.54
9-13	1936	2	2	2	1.48	5.41	.72	71.03	2.51	18.85
9-14	810	2	2	3	1.24	5.34	.66	73.54	2.10	17.12
9-14	1614	4	2	4	2.02	7.02	.58	68.73	1.93	19.72
9-14	2002	3	2	5	1.94	6.00	.61	70.73	2.15	18.57
9-15	952	4	2	6	1.29	5.20	.63	73.13	2.48	17.27
9-15	1145	2	2	7	1.27	5.58	.65	72.36	2.26	17.88
9-15	1425	4	2	8	1.41	5.44	.87	71.54	2.14	18.60
9-15	1545	1	2	9	1.33	5.89	.82	70.89	2.73	18.34
9-15	1620	4	2	10	1.37	5.51	.81	70.50	2.51	19.30
9-15	1950	4	2	11	1.48	6.32	.66	69.69	1.98	19.87
9-16	750	4	2	12	1.13	4.78	.77	73.32	2.04	17.96
9-18	1346	1	2	13	1.34	5.26	.86	69.20	2.26	21.08
9-18	1622	1	2	14	1.35	5.57	.88	70.72	2.18	19.30
9-18	1750	4	2	15	1.56	5.47	.97	71.39	2.80	17.81
9-19	812	2	2	16	1.23	5.49	.76	70.48	2.50	19.54
9-19	1348	4	2	17	1.32	5.67	.87	68.84	2.50	20.80
9-19	1724	1	2	18	1.25	6.04	.77	69.88	2.54	19.52
9-20	847	1	2	19	1.33	5.58	.81	73.79	2.17	16.32
9-20	1706	1	2	20	1.30	5.77	1.03	68.97	2.69	20.24
9-21	630	1	3	21	1.53	5.80	1.05	67.72	2.81	21.09
9-21	1505	3	3	22	1.38	5.58	.98	68.53	2.47	21.06
Average					1.42	5.70	.80	70.63	2.37	19.08

An accurate record of total weight and composition of chopped corn was obtained during the filling operation. In order to determine losses in storage additional samples were taken while the silo was being unloaded.

After analysis these samples were compared as nearly as possible with the corresponding in-going sample. The results are shown in Table II.

Table II. Composition of Fresh Chopped Corn Compared with Cured Silage

Date	Ash	Crude Fiber	Ether Extract	H_2O	Protein	N-Free Extract
In 9-19-61	1.32	5.67	.87	68.84	2.50	20.80
Out 12-18-61	1.35	5.59	1.09	69.76	2.55	19.66
In 9-18-61	1.56	5.47	.97	71.39	2.80	17.81
Out 1-19-62	1.27	6.13	1.13	69.45	2.78	19.24
In 9-18-61	1.35	5.57	.88	70.72	2.18	19.30
Out 1-23-62	1.19	6.38	1.01	68.81	2.51	20.10
In 9-16-61	1.34	5.26	.86	69.20	2.26	21.08
Out 1-27-62	2.23	5.70	1.64	54.20	3.83	32.40
In 9-14-61	1.94	6.00	.61	70.73	2.15	18.57
Out 3-17-62	1.25	6.49	.74	69.72	2.44	19.36
In 9-13-61	1.59	6.69	.87	68.85	2.47	19.54
Out 4- 2-62	1.36	5.00	.37	79.49	2.08	11.70
In-Average	1.51	5.77	.84	69.95	2.39	19.51
Out-Average	1.44	5.88	.99	68.57	2.69	20.41

All silage removed during the feeding period was weighed as it was fed. Total weight removed amounted to 2,260,210 pounds. This compared with 2,708,970 pounds weighed into the silo shows a loss of 448,760 pounds. This represents a total loss in weight during storage of 16.6 percent and the total loss in dry-matter of 11.5 percent.

Part of this loss can be determined from this experiment whereas certain other losses must be identified from other research.

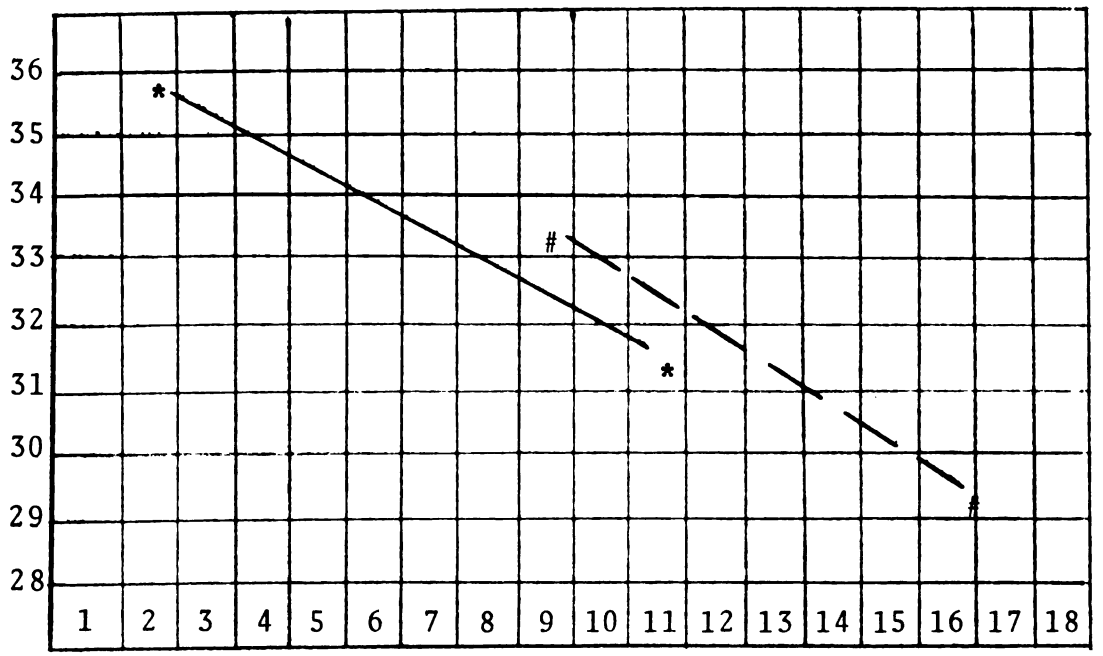
For example, a USDA study, "Estimating the Quantity of Settled Corn Silage in a Silo"[6] indicated lower storage losses as dry-matter of silage increased. Three silos filled with corn silage with a dry-matter percent of 32.0 to 29.1 resulted in dry-matter losses of 8.4 to 11.8 percent respectively. A Minnesota researcher reported a dry-matter loss of only one percent for 123 tons of 34 percent dry-matter corn silage stored in a concrete stave silo and covered with a plastic cap.[11]

The average moisture content of the 30' x 70' silo filled in 1961 was 70.63 providing 29.37 percent dry-matter. Considerable seepage was observed. Accordingly, the moisture content of the silage unloaded averaged 31.43 percent or a difference of 2.06 percent.

Moisture and dry-matter figures for the 30' x 70' silo filled in 1962 indicate the significance of lower moisture levels as they relate to dry-matter losses. The dry-matter content of the

1962 silage as it went into storage averaged 33.3 percent or nearly four percentage points higher than for the previous year. Total loss in weight was reduced to 9.2 percent. The dry-matter content of the silage as it was weighed out was 35.8 percent. Total loss of dry-matter during storage was 2.4 percent which vividly illustrates the importance of increasing dry-matter of corn silage to at least 32 percent. (Figure 2 illustrates this point.)

Figure 2



Percent Loss

* Percent loss of dry-matter
\# Percent loss in weight

Thus far corn silage storage losses from the standpoint of total weight of silage and dry-matter have been discussed. In an effort to determine what these losses might mean in terms of nutrients a comparative analysis of in-going and out-going silage samples

was completed. An attempt was made to compare samples from the same location in the silo (in-going and out-going).

Table III illustrates the total digestible nutrients found in six samples collected at filling time and six samples extracted from the silo during the feeding period from similar locations in the silo. TDN has been calculated on a dry-matter basis.

Table III. TDN Values for Fresh Cut Corn ("in" samples) Compared with Cured Silage ("out" samples) Calculated on Dry-Matter Basis

	Date	Crude Fiber	Ether Extract	Protein	N-Free Extract	Total TDN	% TDN DM Basis
In	9-19-61	3.63	1.53	1.38	15.39	21.93	70.38
Out	12-18-61	3.57	1.91	1.40	14.55	21.40	70.86
In	9-18-61	3.50	1.70	1.54	13.18	19.92	69.67
Out	1-19-62	3.92	1.98	1.53	14.24	21.67	70.91
In	9-18-61	3.56	1.54	1.20	14.28	20.58	70.22
Out	1-23-62	4.08	1.77	1.38	14.87	22.10	70.82
In	9-16-61	3.37	1.51	1.24	15.60	21.72	70.59
Out	1-27-62	3.65	2.87	2.11	23.97	32.60	71.17
In	9-14-61	3.84	1.07	1.18	13.74	19.83	67.85
Out	3-17-62	4.15	1.30	1.34	14.33	21.12	69.86
In	9-13-61	4.28	1.53	1.36	14.46	21.63	69.41
Out	4- 2-62	3.20	.65	1.14	8.66	13.65	66.64
In-Average		3.69	1.48	1.31	14.44	20.93	69.68
Out-Average		3.76	1.74	1.48	15.10	22.09	70.04

These data do not indicate significant differences. However, they do demonstrate the need for more accurate procedures in obtaining samples for analysis.

DENSITY OBSERVATIONS

During the feeding period and in conjunction with the weighing out procedure some measurements were made in an effort to determine weight of silage per cubic foot at various heights in the silo.

The procedure used was to mark the silo wall in several places at the silage level. Then the depth of silage was recorded. After several days of feeding another series of marks were made and the average distance to the previous marks determined. The volume could then be calculated and related to the weight of silage removed. This technic of measuring density is known as the layer method. Locations of density measurements are illustrated in Figure 3.

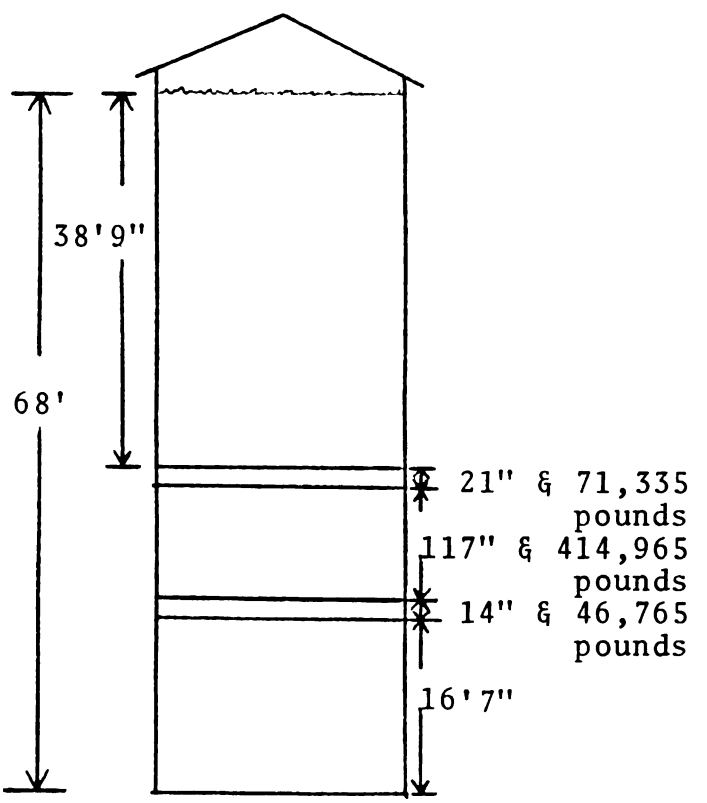


Figure 3. Location of Density Measurements

The silo was filled to a height of seventy-two feet and then refilled the following day. Final settled height was sixty-eight feet.

Since numerous studies of density had been made to depths up to forty feet the first layer measurement was established after nearly forty feet of silage had been removed. When the silage level was 29 feet 3 inches from the bottom the first series of marks were made on the wall. Four days later 71,335 pounds of silage had been removed lowering the level by 21 inches.

The second series of marks were made after 117 inches of silage and 414,965 additional pounds were removed lowering the silage level to 17 feet 9 inches. The average depth of this layer was 22 feet 7 inches. The third and final layer involved three days feeding and 14 inches of silage. 46,765 pounds were removed. Table IV provides average weights of silage removed per inch of the three locations measured.

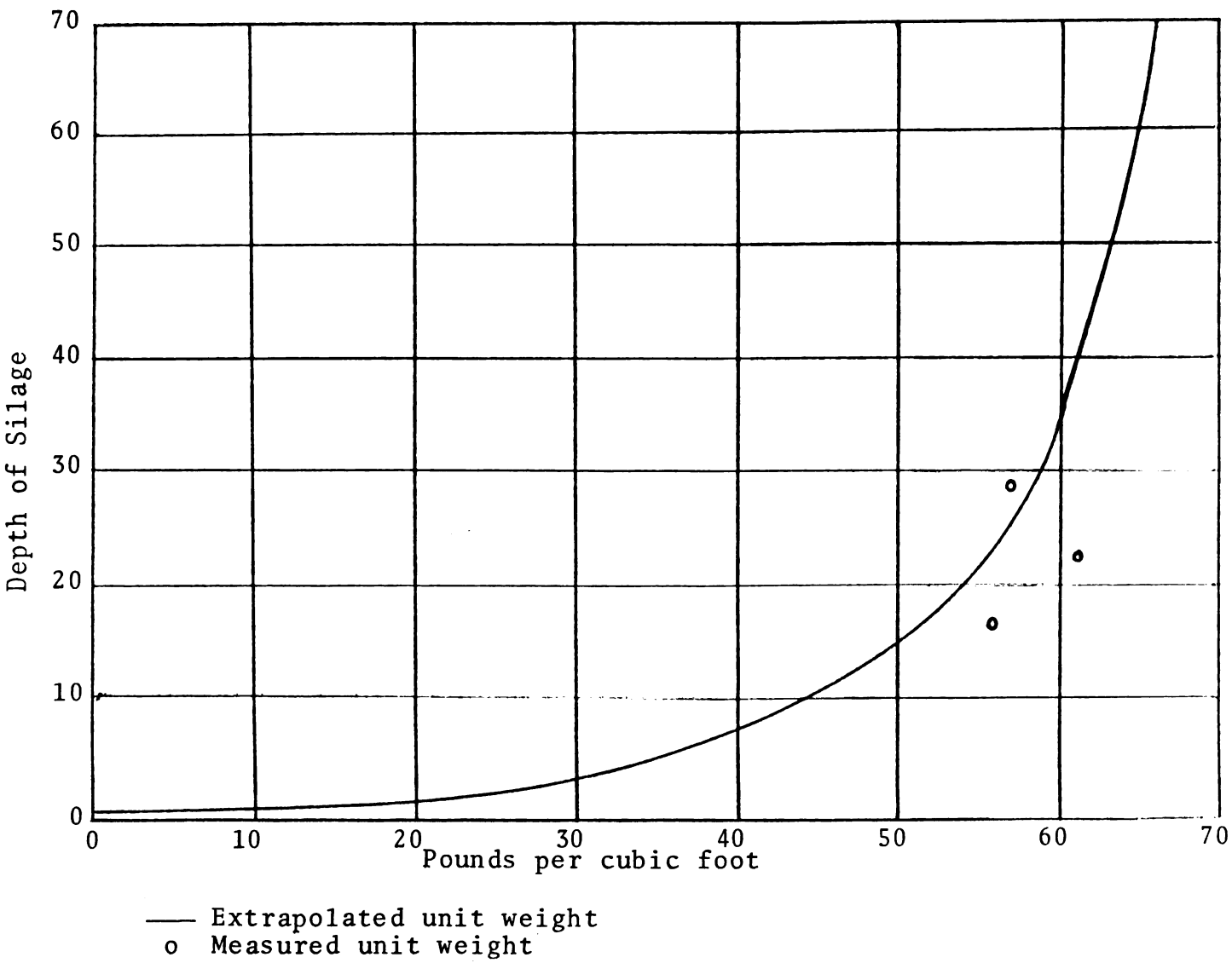
Table IV. Weight of Corn Silage per Inch of Depth in Three Locations of a 30' x 70' Silo

Depth of Silage	Inches Removed	Weight Removed (lbs.)	Weight Per Inch (lbs.)
29 ft. 3 in.	21	71,335	3,380
22 ft. 7 in.	117	414,965	3,547
17 ft. 9 in.	14	46,765	3,320

Additional calculations made from the measured layers included weight per cubic foot. The unit weight computed from the first layer at 29 feet 3 inches of depth amounted to 57.28 pounds per

cubic foot. The second weight from an average depth of 22 feet 7 inches was 60.5 pounds per cubic foot. The final layer provided a unit weight of 56.27 pounds. These weights (Figure 5) when compared to extrapolated figures provided by R. A. Aldrich[2] fall in the same general area.

Figure 5



SUMMARY AND CONCLUSIONS

An investigation was carried out to determine the tons of corn silage of a given moisture content that can be stored in a 30' by 70' concrete stave silo.

All material was weighed and sampled at filling time and again during the feeding program. This experiment involved filling 30' by 70' silos over three different years and comparing the data accumulated.

In 1961 considerable uniformity of composition of silage was experienced during the filling period which spanned nine days. Samples were frozen for preservation and then analyzed at one time in the Michigan State University Bio-Chemistry Laboratory.

Comparison of tonnages over the three years showed a variation of forty-nine tons. The apparent cause of this variation is the fineness of chop and moisture content since the silos were filled to the same heights and refilled similarly.

Quite a different situation occurred during unloading of the silos. Using the layer method to determine density at three different locations wide variation in weight per inch of depth and per cubic foot were encountered. In addition considerable variance was observed in moisture content. These factors indicate an unreliable sampling method and the affect of the silage density diminishing as material is removed; this might be called "spring back."

A conclusion can be drawn concerning the significance of moisture content in harvesting corn silage. This work clearly shows lower weight losses in the material as the percent of dry-matter increases. Likewise, lower losses in dry-matter occurred. These results agree with other research cited in this paper involving smaller silos. Losses increased rapidly as silage dry-matter fell below thirty-two percent.

An attempt to determine the effect of storage on the nutrient composition of silage indicated little change occurring. Here again difficulties were encountered in making an accurate comparison of samples from in-going and out-going silage. An attempt was made to relate out-going samples with in-going samples in the same location. Paired samples which would be identical are needed for accurate comparison of total digestible nutrients. Despite wide variations in samples however, the average composition of in-going corn compared with out-going silage were similar.

A greater percentage of loss in weight and dry-matter occurred than in digestible nutrients. Samples analyzed indicate no loss in nutrients due to fermentation or storage under the conditions of this investigation.

RECOMMENDATIONS FOR FURTHER STUDY

It is considered that before accurate quantities and determinants for silage composition can be developed additional study is needed concerning experimental methods.

Several problems exist because of the quantity of material to be handled and its perishibility. Problems needing further investigation might include the following:

1. A density study is needed on silage to determine the response from removal of material.
2. Work should be done to develop a procedure for more accurate sampling including paired samples for identical comparison.
3. Additional work is needed to identify more specifically what losses occur.
4. Develop a sampling method from within the silo to assure better representation.
5. A study of the opportunities to develop a more meaningful method of measuring the capacity of a silo in terms of feed quantity and value is needed.

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