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SILAGE INVESTIGATIONS

By

H. W. Cave

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SILAGE INVESTIGATIONS.

Although the increase in popularity of silage as a food for all classes of livestock has been phenomenal, especially in the last twenty years, information on many questions in regard to its use has been very meager. It was the purpose of this study, begun in the fall of 1914, to attempt an answer of some of the more common questions. So many factors enter in and so much variation occurs in the data that a long time observation would be necessary to draw accurate conclusions in many cases.

The questions under investigation were: (1) The weight of normal silage and factors influencing it. (2) The normal temperature of silage and its relation to weight, moisture and acidity. (3) The preparation of silage from corn and cane.

Literature--The review of previous investigations which follows includes all which bear upon the various subjects included in this investigation.

1. Professor F. H. King of the Wisconsin Experiment Station is the only one who has published data on the weight of normal silage, (Wis. Sta. Bul. #59), and his work dealt with corn silage only. His table follows:

Table showing the computed weight of well-matured corn silage at different distances below the surface, and the computed mean weight for silos of different depths, two days after filling.

Depth of Silage, feet.	Weight of Silage at different depths.	Mean weight of Silage per cubic foot.
1	18.7 lbs.	18.7 lbs.
2	20.4	19.6
3	22.1	20.6
4	23.7	21.2
5	25.4	22.1
6	27.0	22.9
7	28.5	23.8
8	30.1	24.5
9	31.6	25.3
10	33.1	26.1
11	34.5	26.8
12	35.9	27.6
13	37.3	28.3
14	38.7	29.1
15	40.0	29.8
16	41.3	30.5
17	42.6	31.2
18	43.8	31.9
19	45.0	32.6
20	46.2	33.3
21	47.4	33.9
22	48.5	34.6
23	49.6	35.3
24	50.6	35.9
25	51.7	36.5
26	52.7	37.2
27	53.6	37.8
28	54.6	38.4
29	55.5	39.0
30	56.4	39.6
31	57.2	40.1
32	58.0	40.7
33	58.8	41.2
34	59.6	41.8
35	60.3	42.3
36	61.0	42.8

The Missouri Station attempted in 1914-15 to secure some information on silage weights but the results were unsatisfactory.

2. Eckles, Oshel, and Magruder of the Missouri Station (Research Bulletin #22) in 1913-14-15 made some investigations on silage temperatures and factors influencing it. They found that the maximum temperature of silage was rarely over 100 degrees F, generally ranging from 75 degrees to 90 degrees F, the greatest factor influencing it being the amount of air in the silage. Lack of moisture or poor packing fails to exclude the air, so that mould growth and a higher temperature results. They decided that under ordinary conditions temperature was not an important factor, as proper fermentation to produce good silage was found to take place in cane held at 50 degrees F, 68 degrees F, and 100 degrees F. The temperature of the air at filling time was found to have some effect on the temperature attained by the silage, but the material used in the construction of the silo was found to have little effect on the temperature.

3. R. E. Neidig of the Iowa Experiment Station (Research Bulletin #16) reports a maximum temperature of 91 degrees F in a concrete (18 days after filling), a tile (9 days after filling) and 86 degrees F in a stave silo (20 days after filling. The temperatures were taken with electric resistance thermometers.

4. Ester and Mason of Storrs Experiment Station

(Bulletin #70) report maximum temperatures of 80.6 and 80.4 degrees F. They consider 75 to 85 degrees F the best temperature for silage production, over 100 degrees F being destructive and under 65 degrees F being too low a temperature for the production of good silage. They claim that concrete, stone and brick silos conduct heat away too rapidly, but this was later denied by the director of the Storrs Station.

5. Babcock and Russell of the Wisconsin Station (Wisconsin Station Annual Report 1901) attribute the heat generated in the silo to intromolecular respiration of the ensiloed material and claim that it is not essential to silage production. They got good silage from containers kept under conditions at controlled temperature (60 to 70 degrees F).

6. The Vermont Station reports a maximum temperature of 80 degrees F on the second day after filling and a gradual decline in 21 days to 60 degrees F (Vermont Experiment Station Annual Report 1889).

7. The Wisconsin Station reports a maximum temperature of 163 degrees F, one week after filling, in a small, square experimental silo (Wisconsin Bulletin #19).

8. The New Hampshire Station (Bulletin #79) reports a maximum temperature of 103 to 127 degrees F from two to forty-three days after filling.

9. The Michigan Station (Woll--A Book on Silage) found a direct correlation between moisture and acidity. The

results are reported as follows:

Date of Cutting.	Water Content, %.	Acidity (calculated as acetic acid).
Aug. 10	90	1.26
Aug. 16	87.3	.84
Aug. 22	84.4	.76
Aug. 28	82.0	.72
Sept. 3	78.6	.72
Sept. 9	75.73	.72
Sept. 14	70.1	.70

10. Well of the Wisconsin Station (Woll--A Book on Silage) found the maximum temperature attained by the silage mass to be affected by the water content, the lower percentage of water causing a higher maximum temperature to develope.

	Water Content	Acidity	Maximum Temperature
Sweet corn	77.22	1.31	125.6 F
yellow dent	71	.48	120.0 F
Yellow dent (partially cured)	34.77	.14	153.0 F

11. The Vermont Station (Bulletin #170) reports good success from ensiloed corn fodder when 12¼ tons of water were added to 8 tons of shredded fodder. The final product contained 25% of dry matter, was relished by the stock and was an efficient milk producer.

12. The Missouri Station (Circular #71) in 1913-14 filled three small experimental silos with shock corn and varying amounts of water were added. There was also an investigation made of farms where fodder was ensiloed.

They decided that the material so treated made satisfactory feed but not equal to corn put in at the proper stage.

The best results were obtained where equal weights of shock corn and water were used.

The Weight of Normal Silage and Factors Influencing It.

This question is of great importance to the silo owner or prospective owner as it is necessary that he have an idea of the capacity of different sized silos in order to know how much of his silage crop to grow or how large a silo to construct in order to supply sufficient feed for his stock. Especially of recent years a good deal of silage has been sold in the silo and this requires figures for estimation. Many silo owners have been disappointed in their silos not holding the capacity rated from King's tables. This is more often true of high silos. The Dairy Department of this institution has two silos rated at something over 90 tons capacity but the most ever gotten into either of them by actual weight of the material put in was 82 tons.

That it is a pertinent question is shown by the fact that farm papers, nearly all year round but more especially at silo filling time, contain numberless inquiries concerning silage weights and silo capacities.

The only figures on silage weight were compiled by Professor F. H. King of the Wisconsin Station in 1897 and they have been the basis of the answers to these inquiries. Many have felt that these figures were deficient in many respects but had nothing better to offer.

The Missouri Station attempted some work on silage weights in 1914-15 but the results were unsatisfactory and nothing was ever published.

The Wisconsin Station has been and still is working on the question. Nothing of King's method of procedure was ever published but that his figures may be rather questioned is brought out by a letter from Professor F. M. White of that station written in reply to inquiry made by the writer in regard to how Mr. King obtained his figures. A copy of this letter may be seen in Fig. 1.

In an attempt to throw some light on the subject, the writer began some work in the fall of 1914 using the contents of a metal lath (16 by 25') and two stave silos (16 by 25' and 16 by 30') at the college dairy barn and on one monolithic silo (16 by 46') located at the Animal Husbandry experimental feeding sheds. The plan was to weigh a representative cubic foot from each foot layer as the silage was fed down, starting at the top of the full silo. The rotted material, always found on the surface of silage which has stood for some time, was thrown off before the first weight was taken.

Due to the fact that varying amounts of silage were being fed from the surface it was not always possible to take the weights at exactly one foot intervals.

Fig. 1.

Madison, Wisconsin,
May 2, 1916.

Mr. H. W. Cave,
Manhattan, Kansas.

Dear Sir:

In regard totthe work done by Mr. F. H. King in determining the capacity of silos, at the time he did his work silage was not considered valuable. We had on the University Farm a silo which he filled and after it had settled he emptied the entire silo, keeping track of weights. This was carried on for three or four years and of course the silage was a total waste.

We have attempted for the last few years to determine the capacity of silos by keeping track of the weights as it is removed. This has not been at all satisfactory and so last year we made some collapsible boxes for trial. These have not yet been removed and I cannot make any statements regarding the success with them.

Very truly yours,

(Signed) F. M. White
Agricultural Engineering Dept.

The work was continued in 1915-16 with two dairy stave silos, the Animal Husbandry monolithic and four silos near Manhattan known as Dicken's concrete (14 by 32.5'), Morey's concrete (14 by 30'), Hudson's wood stave (14 by 26.5') and McManus' wood stave (14 by 30').

The materials used in filling these silos were corn, kafir and cane. Those of corn and kafir will be seen in table 111.

The apparatus used for obtaining a cubic foot of silage was on designed by the dairy department of this institution and is illustrated in Fig.11. It is exactly one foot square, outside measurement, and the tines proper are just one foot long.

The method of procedure in obtaining a cubic foot of silage for weighing was as follows: The surface of the silage, midway between the center and the wall of the silo, was carefully leveled down to firmly packed silage, then the apparatus was driven into the first band making the points of the tines exactly one foot down in the silage. With a common hay knife the silage was then carefully cut around the outside of the apparatus to a depth of approximately one foot. The enclosed silage was then removed by hand down just to the points of the tines, was collected in a basket or sack, weighed, and a sample was taken for moisture analysis. After weighing and sampling, the remainder was ~~transferred~~

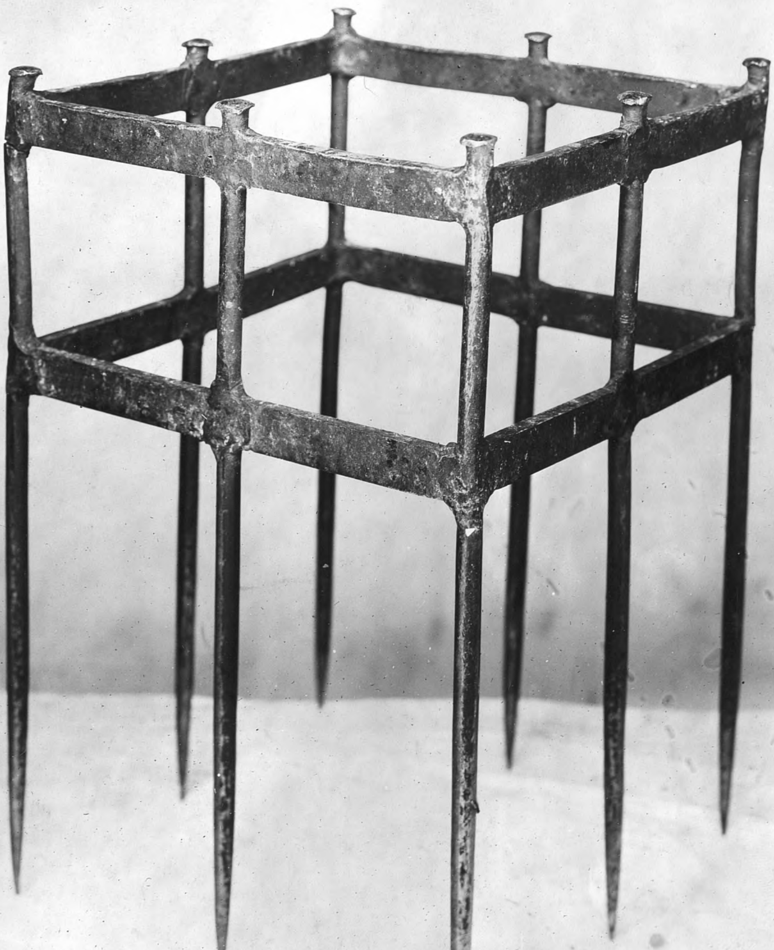

Fig. II.
Apparatus for obtaining a cu.ft. of silage

tramped back into the hole.

The moisture was obtained by weighing out a one kilogram sample and drying to constant weight in the air. This would vary slightly with the humidity of the air but gives good comparative results.

Factors affecting weight--

The following are the factors which appear to have the most direct bearing on the actual weight of silage in the silo.

1. Depth.
2. Moisture
   a. Maturity of crop
   b. Kind of crop
   c. Moisture added.
3. Fineness of cut
   a. Type of machine
   b. Set of blades
   c. Sharpness of blades
   d. Kind of crop
   e. Maturity of crop.
4. Kind of crop.
5. Tramping (all centers or side).
6. Per cent of grain.
7. Inside finish of silo (rough finish will prevent settling).

Factors affecting experimental weight other than those given are as follows:

1. Center or side of silo. Friction on the side of silo has a tendency to prevent settling so we might expect a lower weight per cubic foot here than in the middle.

   In order to test this out, all weights in two silos were taken in duplicate, one foot being taken at the side and the other in the middle. The results appear in the following table.

Table 1.

	Av. Weight at Center	Av. Weight at Side	Difference
Metal lath silo	37.8 lbs.	35.2 lbs.	2.6 lbs.
Dairy Stave silo	39.6 "	38.6 "	1.6 "

In both cases the weights at the center averaged higher than at side.

2. Firmness of packing. Especially in loose silage there may be some compacting during the sett#ing of the apparatus.
3. Spring to silage. It is possible that silage, toward the bottom of the silo, packed under extreme pressure, may spring back to some extent when this weight of upper silage is removed.
4. Settling of apparatus. Especially near the top of the silo or in loosely packed silage, there is a tendency for the heavy steel apparatus to settle when most of the contained cubic foot has been removed.
5. Tendency of knife to deviate out (can never deviate in).
6. Crumbling in from side of hole.

Most of these factors would tend to give too high a weight of the cubic foot obtained with the apparatus. In order to check up on this point the whole amount of silage, for three feet in the dairy stave silo,was weighed. The method of procedure was as follows:

At about the twenty-first foot the surface of the silage was carefully leveled down to firmly packed silage with a straight-edge, and this level marked with a white crayon around the side of the silo. Then two cubic feet were removed with the apparatus and weighed, their average weight being taken as the experimental weight at this depth. All silage removed between the twenty-first and twenty-second feet was carefully weighed. As the twenty-second foot was approached the process of leveling with the straight-edge was repeated, the silage surface being brought to an exact level at the twenty-second foot. The total weight in that foot layer was divided by the cubic feet contained in it and this gave the average actual weight per cubic foot.

The whole process was repeated with the twenty-second and twenty-third feet.

The following table shows the results obtained.

Table 11.

	Apparatus Average	Actual Average	Difference
21st ft.	37.6 lbs.	34.4 lbs.	3.2 lbs.
22nd ft.	40.0 "	35.9 "	4.1 "
23rd ft.	41.8 "	39.7 "	2.1 "
Average	39.8 "	36.66 "	3.14 "

From these figures we would draw the conclusion that the weight taken with the apparatus was high. The correction factor in this case would be .9211.

Table 111 shows all the weights taken in the corn and kafir silos and the averages drawn for each foot.

Although quite wide variations may be observed in Table 111 it was noticed that wide variations also occurred in the moisture content at different depths which of course has a direct influence upon the weight. The average of all weights taken in corn silos was 41.1 pounds per cubic foot but this could hardly be taken as the true average as the weights of the first few feet were not obtained in some silos. If these were included the average would probably be somewhat lowered. This average reduced by the apparatus correction factor would be 37.86 pounds per cubic foot.

The average air dry moisture of all cubic feet weighed was 66.38%. The average of all silos for each cubic foot from one to thirty-two is shown graphically in Fig. 111.

From Fig. 111 it is noticed that there is not a regular increase in weight from top to bottom of the silo, but rather the weights seem to follow three definite lines. There is a rapid increase for the first ten feet, then for ten or twelve feet the weights run more nearly constant, then there is a sharper rise in the mean weight toward the bottom of the silo. A possible explanation may be as follows:

The first ten feet the weight increases quite rapidly

Table 111. (Corn Silos)

Depth	No. 2 Stave	A. H. Cement	Morey Cement	Hudson Stave	No. 3 Stave	Metal Lath	No. 2 Stave	Average
1 ft.	38.8			38.0	28.8			35.2 lbs.
2				38.6	33.6		36.7	36.3
3							36.5	36.5
4				40.2	34.3		35.0	36.5
5		39.6			35.2		34.0	36.3
6				42.4	37.1		39.3	39.6
7		42.5		42.6	39.6		41.4	41.5
8		43.6	32.4		40		42.6	39.7
9	40.3	44.0	31.8	37.2			46.4	39.9
10		42.8		43.2	39.1		40.3	41.4
11	36.2	45.1	33.2	34.8	38		41.2	38.1
12			41.0	37.2	40.8			39.7
13	34.2	46.4	40.7	40.0	38.0			39.8
14	37.5	48.6	42.0	41.0	37.2	34.4	39.1	39.9
15	36.8	48.8	42.6	40.5	37.0	37.2	36.6	39.9
16	37.0	49.0		41.2	37.2	36.1	39.4	39.9
17	37.5	49.0		41.8	37.2	33.3		39.8
18	37.7	48.4	41.2	42.6	35.6	36.4	40.2	40.3
19	38.0	46.2	41.6			44.8	40.5	42.2
20	36.8					40.1	38.9	38.6
21		47.0			37.6	38.0		40.9
22	38.4	47.0			40.0	40.0		41.4
23	39.2	48.1			41.8			43.0
24	38.2	48.8			41.0			42.7
25	39.0	48.6			40.5			42.7
26	40.1	49.6			41.0			43.6
27		49.5			42.2			45.9
28		50.1			42.8			46.4
29		47.0						47.0
30		47.0						47.0
31		46.4						46.4
32		49.8						49.8

Table 111 Continued. (Kafir Silos)

Depth	Metal Lath	Morey Cement	A. H. Cement	Average
1 ft	40.3	25.6	33.4	33.1 lbs.
2		28.5		28.5
3	37.7	36.5	34.6	36.3
4	34.4	37.2		35.3
6	34.8	34.6	35	34.8
7	33.8			33.8
8	34.6			34.6
9	35.7		34.2	34.9
10	36.0		35	35.5
12	37.6			37.6
13			37.2	37.2
15			36.6	36.6
17			37.2	37.2
19			38.6	38.6
20			42.6	42.6
23			42.6	42.6
25			39.4	39.4
27			39.	39.0
29			39.4	39.4
30			41.4	41.4
31			43.8	43.8
32			43.6	43.6
33			43.2	43.2
34			42.8	42.8
35			43.0	43.0
37			44.8	44.8

as the pressure increases but at about ten feet the point is reached where the increased pressure cannot make a corresponding increase in weight, as there is a limit to the compressability of any substance, so the weights remain more constant for some distance down. As the bottom of the silo is approached, in nearly all cases a rise is noticed in the moisture content, and this may cause a corresponding rise in the weight curve.

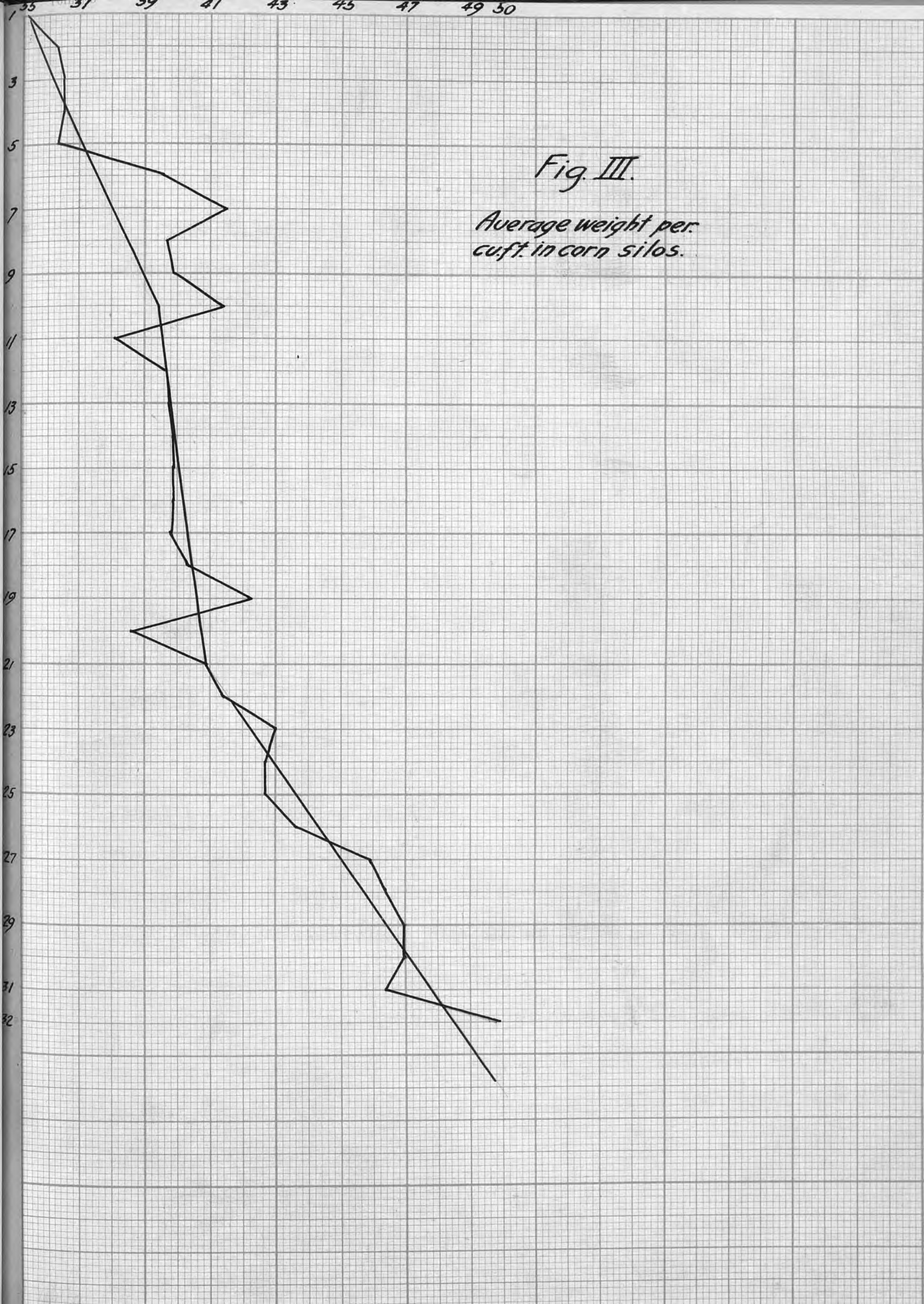

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Fig. III.
Average weight per cu.ft. in corn silos.

The formulae for obtaining the weight at any given depth, based upon the data of this experiment, are as follows:

1 to 10 feet--- W equals .4d plus 35.0
11 to 21 feet W equals .14d plus 38.0
21 to 32 feet W equals .68d plus 26.6
W equals weight; d equals depth.

The most noticeable difference between the figures of King and those of this experiment was the much larger range of weights in King's table. His average for the first foot is 18.7 pounds, while the writer's lowest weight for this foot was 28.8 pounds in what was considered dry silage, while the majority of the surface weights were over 35 pounds. The average for this foot, 35.2 pounds, corrected for experimental error, is 32.4 pounds, which is still much higher than King's average. Then King gives 58 pounds as the average for the thirty-second foot, while the heaviest weight found by the writer at this depth was 49.8 pounds and this was in very hard packed and rather damp silage. This weight corrected for experimental error would give 45.9 pounds, even a wider variation. The table of King also shows an almost constant increase from the top to the bottom of the silo which does not seem probable. The writer believes that it would be impossible to obtain such a true mathematical increase, experimentally, and especially from the small amount of data collected by King.

Weights of kafir silage were taken in three silos, but only one, the Animal Husbandry in 1916, was complete. Morey's cement contained a few feet of kafir on top of the corn, and the metal lath in the fall of 1914 was filled with kafir but was refilled after about twelve feet had been taken out so the figures were not complete.

The average of weights observed was somewhat lower than that of corn, being 37.47 pounds per cubic foot with 60.4% air dry moisture. The weights are shown in Table 111. Greater variations are observed in the case of kafir than that of corn, due probably to the small amount of data.

Cane silage was weighed in two silos. MacManus' stave and Dickens' cement, but was unsatisfactory in both cases, as the stave silo blew down when half emptied, spoiling the depth calculations, as the places at which weights had been taken were marked inside the silo. Dickens' silo was filled with a mixture of very mature and very green cane, and the different layers were very noticeable as the silage was removed. For this reason the weights showed great variation and were valueless.

In order to contrast silage capacity as figured by King's tables with the capacity estimated from the data of this experiment, the most representative of the corn silos were used. This is shown in Table 1V.

Table 1V.

		King	Actual
Hudson Stave	(1st to 18th foot)	44.18 T.	55.53 T.
No. 3 Stave	(" " "? ")	101.87	100.81
No. 2 Stave	(2nd " 20th ")	65.15	75.34
A. M. Cement	(5th " 32nd ")	122.47	131.40
No. 2 Stave	(11th" 26th ")	70.95	60.27

As might be expected, the low silos show a greater capacity when estimated by actual figures than when estimated by King's tables, as King shows such very low weights on the first eight or ten feet in the silo. It will be noticed that in the case of the stave silo No. 2 where the silage was estimated from the eleventh to the twenty-sixth foot, that King's estimate is over the actual as these first ton weights of King's estimate are there eliminated.

In the case of the Animal Husbandry cement silo,from the fifth to the thirty-second foot, the actual exceeds King's, due to the fact that this silage was quite wet throughout and the actual weights ran very high, the average per cubic foot being 46.91 pounds.

Silo No. 3 shows almost the same capacity by both estimates. Here King's weights being low for the first few feet and high for the last few the average is about the same as for the actual figure.

The Normal Temperature of Silage and its Relation to Weight, Moisture and Acidity.

In order to establish a relationship between the weights temperature, moisture and acidity, temperatures were taken in a number of silos in 1914-15 in which weights were being taken. These temperatures were taken in two ways, by means of gas pipes in which thermometers were raised and lowered, and by means of electric resistance thermometers. This apparatus consisted of a portable indicator and resistance bulbs which might be buried at any spot in the silage. Wires enclosed in 3/8 inch lead pipe for protection led from the bulb to the surface of the silage where they could be attached to the indicator and by passing a current of electricity through the bulb from small batteries in the indicator. The temperature in degrees Centigrade could be read direct.

It was planned to carry out the temperature work on a larger scale in 1915-16 using the electrical apparatus altogether but due to a change in the method of installing the leads very few satisfactory temperatures were obtained. The silos used were the Animal Husbandry monolithic and the Stave Silo No. 2 at the College Dairy Barn, in which the temperatures were taken with the thermometers in pipes, and the metal lath and new wood stave, both at the Dairy Barn, in which the temperatures were taken with the electrical apparatus.

The wall temperatures were taken at a point about six inches from the wall, midway between the top and bottom of the silo, and was accomplished by placing the lower end of the gas pipe in one case, or the resistance bulb in the other, at this point. The center temperatures were taken at the same level as the wall temperatures but in the center of the silo. The surface temperature was obtained by simply running a thermometer bulb a few inches into the surface of the silage and the air temperature by a thermometer hanging four or five feet above the silage.

The temperatures were taken daily for a period of nearly six months, starting immediately after the silo was filled.

As the most important changes in temperature come within a few days after filling, the temperatures in detail are shown for only the first thirty days after filling. These temperatures and the dates the silos were filled appear in Table V.

From this table it will be seen that the temperature of the silage rises for the first few days and then gradually falls.

The maximum temperature of the wall in all cases noted was reached within a week after filling. The maximum at the center in all but one case was reached at a later date than the maximum of the wall, and in every case the maximum temperature at the center was higher than that at the wall.

This lower temperature at the wall is undoubtedly due to the fact that heat is conducted from the silage by the wall.

North Wood Stave — Table V. — Filled Aug. 21-22

Date	Air Degrees F	Surface Degrees F	Wall Degrees F	Center Degrees F
Aug. 23	76	119	104	101
24	86	120	104	104
25	81	112	106	104
26	78	117	103	109
27	76	88	99	109
28	68	90	99	104
29	76	86	100	109
31	92	95	97	
Sept. 1	84	94	97	107
5	94	104	97	106
8	70	119	93	101
9	83	119	93	101
10	70	122	93	104
11	72	122	92	104
12	67	122	92	106
13	78	122	90	107
14	74	120	92	107
15	76	122	90	101
16		140	88	109
17		131	90	101
18	76	138	90	108
19		136	90	108
21	79	136	88	108
22	67	136	87	108
A. H. Cement Silo			Filled Aug. 12,13,14	
Sept. 15		136	83	
16		130	83	95
17		138	83	100
19		126	84	90
22		129	83	92
23		128	81	92
24		129	81	92
25	77	129	81	92
26	75	129	81	92
27	77	129	79	92
28	72	128	79	92
29	75	128	79	92
30	76	128	79	92
Oct. 1	74	128	79	92
2	74	128	79	92
3	70	128	79	92

Table V (Continued).

4	68	128	79	92
5	64	128	77	92
6	74	128	77	92
7	74	128	77	92
8	74	128	77	92
9	72	128	77	92
10	64	128	77	92
11	68	128	77	92
12	52	126	75	92
13	47	126	74	92
14	48	128	72	90

Table V (Continued).

Metal Lath. Filled September 26-26

Date	Wall Degrees F	Center Degrees F
Sep. 27	74	71
28	78	75
29	79	77
30	80	78
Oct. 1	81	79
2	82	80
3	80	81
4	79	82
5	78	83
6	77	83
7	78	83
8	79	83
9	78	83
10	77	83
11	75	84
12	74	84
13	72	84
14	68	84
15	66	84
16	65	84
17	66	84
18	68	84
19	69	84
20	70	84
21	70	84
22	70	84
23	71	84
24	70	84
25	68	84
26	67	83

New Wood Stave. Filled September 27-28

Date	Wall Degrees F	Center Degrees F
Sep. 29	76	76
30	82	82
Oct. 1	84	84
2	84	86
3	84	88
4	83	89
5	81	91
6	79	91
7	82	92
8	81	92
9	81	92
10	78	92
11	78	92
12	77	92
13	74	93
14	72	93
15	69	93
16	68	93
17	70	94
18	72	93
19	74	94
20	74	93
21	73	93
22	73	93
23	73	94
24	72	94
25	70	94
26	69	94
27	66	94
28	64	94

The maximum temperatures attained and the number of days after filling the silo, at which the maxima were reached, is best illustrated in Table Vl. In this table are als0 shown the maximum temperatures abtained in a 16 by 44 vitrified tile silo at the A. H. Barn and in three of the small (7 by 16') experimental silos. The temperature is low in the tile silo, due perhaps to the fact that it was filled during very cold weather.

Table Vl.

Silo	Crop	Max. Temp. degrees F. Center	Days After Filling	Max.Temp. degrees F Wall	Days After Filling
A. H. Cement	Corn	100	3	84	5
North Stave	Corn	109	4	106	3
Metal Lath	Kafir	84	15	82	6
New Stave	Kafir	94	19	84	3
A. H. Vit.Tile	Cane			70	6
No. 1 Exp.	Alfalfa	111	4		
No. 4 Exp.	Alfalfa	113	7	(alfalfa & corn chop)	
No. 6 Exp.	Alfalfa and rye	95	6		

Effect of Moisture on Weight, Acidity, and Temperature.

Woll at the Wisconsin Station (Ref. 10) and also the Michigan Station (Ref. 9) found the acidity to vary directly with the moisture, the higher the moisture the higher the acidity, and data taken from this experiment seem to bear out these results. This is shown in Table Vll. The figures in this table on moisture and acidity were obtained by analyzing from five to seven samples from each silo at varying depths.

Table Vll.

Silo	Total Moisture	Av.Wt.per Cubic Ft.	Acidity (Est. as Lactic acid)	Max. Temp. Center	Wall
A. H. Cement	77.8	53.4	2.19	106	106
N. Stave	70.68	37.85	1.79	109	106
No.3 Stave	70.57	38.19	1.76		
Metal Lath	63.70	36.18	1.49	84	82

The presence of air in silage permits the growth of mould and other organisms and the production of greater heat. Moisture facilitates packing so we would expect the silo of higher moisture to be better packed and thus to attain a lower maximum temperature. Woll found this to be true where therewas a marked difference in moisture content of two silos (Ref.10). The Missouri Station found a maximum temperature twenty-three degrees higher in an experimental silo where the material was loosely thrown in than in one well-packed.

Table Vll does not seem to show a direct effect of moisture upon temperature but this may be due to the fact that there is no very marked differences in the moisture content of the silos.

As would be expected, increased moisture causes an increase in weight, the A. H. cement silo showing a very high moisture content (77.8%) and a high average weight (53.4 pounds per cubic foot) while the metal lath silo, with a moisture content of only 63.7%, shows a weight of only 36.18 pounds per cubic foot.

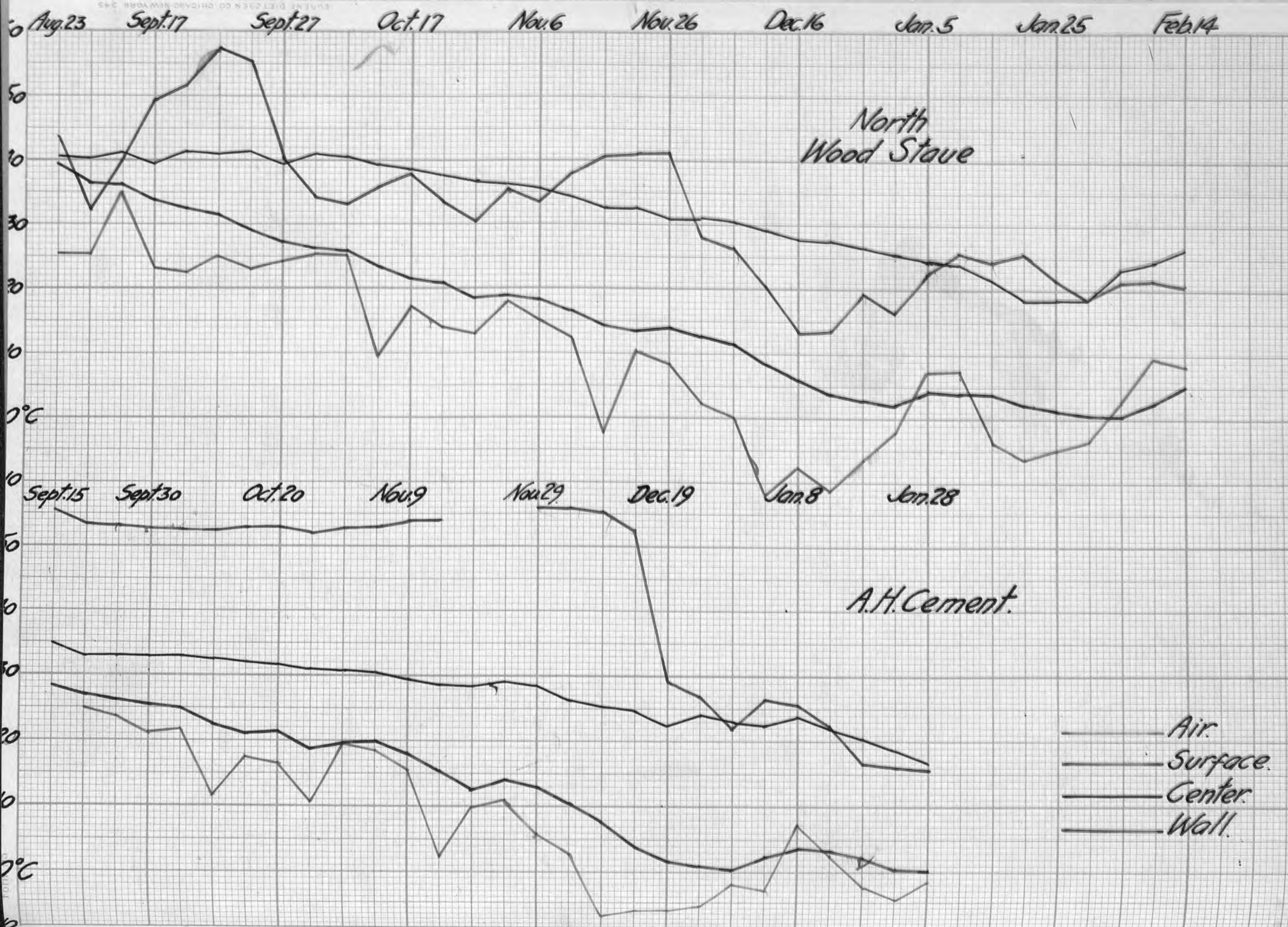
Figuve lV shows the variation in temperatures during the whole period, of the A. H. cement and the north wood stave, while Fig. V. shows the same for the metal lath and new wood stave silos. These temperatures shown are five day averages and are in degrees Centigrade, in order to show them comparatively on the small graphic charts.

Although Ester and Mason (Ref. 4) state that the silos constructed of concrete conduct heat away too rapidly this was not found to be the case in this experiment. The silage in all silos was of good quality and the maximum temperatures were all within the range admitted to produce proper fermentation. The following will show the decline in temperature of the different silos.

Table Vlll

Silo	Days on Test	Max. Temp. Degrees C.	Min. Temp. Degrees C.	Av. decline per day. C
N. Wood Stave	175	39.5	.5	.225
A. H. Cement	135	28.5	.5	.207
New Wood Stave	120	27.5	-.5	.233
Metal Lath	100	26.0	2.5	.235

The metal lath silo shows a slightly greater decline in temperature per day than does the other silos but it is very little greater than the decline in the new wood stave. These were both fourteen feet in diameter while the A. H. and the north wood stave were sixteen feet in diameter, which would have some influence, the smaller diameter tending to make the decline more rapid. The decline in temperature within the A. H. cement silo was the slowest of any



Aug.23
Sept.17
Sept.27
Oct.17
Nov.6
Nov.26
Dec.16
Jan.5
Jan.25
Feb.14
North
Wood Stave
Sept.15
Sept.30
Oct.20
Nov.9
Nov.29
Dec.19
Jan.8
Jan.28
A.H.Cement.
Air.
Surface.
Center.
Wall.

Fig. IV

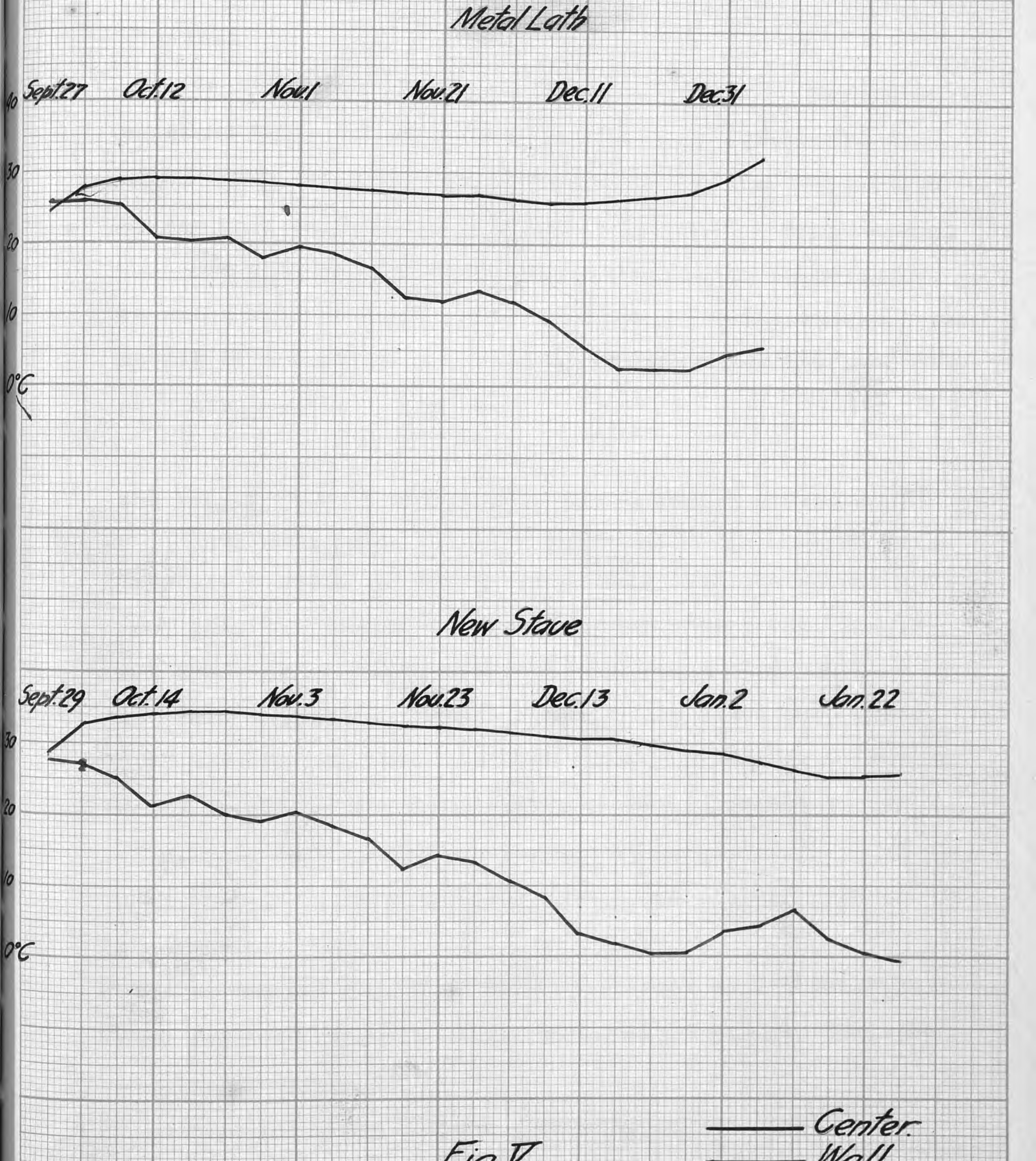


Fig. V

Averaged for
5 day periods

observed.

In all cases the temperature at the center remains more constant than the temperature at the wall, and in the two silos where the air temperature was taken, the temperature at the wall shows a tendency to follow the air temperature.

The time of year at which the decline in temperature is noted will of course have its effect but the observations in all of the silos were made at approximately the same time of year.

The Preparation of Silage from Corn and Cane Fodder----

Many farmers do not have sufficient silo room in which to store a supply of silage which will last throughout the year or even through the winter months when green feed is not available. It often becomes desirable to shock some of the corn or sorghum crops and refill the silo, when empty, with this fodder. The question at once arises as to how much water to add to the dry material to obtain the best quality of silage. Enough should be added to keep the silage in good condition and give sufficient succulence without injuring the nutritive value.

It was the object of this experiment to determine just what per cent of water should be added to produce the best quality of silage.

Corn and sweet sorghum (commonly called cane) fodder were used in the experiment and the method of procedure was exactly the same with each. The word fodder used in this experiment refers to the plant without the grain.

First trial March 20-21, 1915.

The silos used in this experiment were small experimental stave silos 7 by 16' made from three-quarter inch flooring. The corn fodder used had stood in the field all winter and was rather dry but in good fodder condition, the total moisture being 35%. The cane had been piled up during the winter and was in good shape, the stems being quite moist and sweet. Its total moisture was 53%.

This material was run through the silage cutter and water was added to it from a hose running into the blower, and also on top of the full silo in the case of the corn. By means of a water meter the water used was accurately measured. For the first 1200 pounds of corn fodder about six cubic feet of water was used and for the entire silo, containing about four tons, 137 cubic feet or 4.28 tons was used. This is about 107% by weight. It was decided that the cane needed much less water than did the corn, so only a small stream was run into the blower. Nine tons of cane fodder were put into the second silo and in all seventeen cubic feet (1062 pounds) of water were added, which is about six per cent. The cane came out of the silo rather dry but was considered good feed.

In order to make accurate tests of what amount of water was best to add to fodder, unwatered material was taken after passing through the cutter and different amounts, by weight, of water were added and thoroughly incorporated by sprinkling on with a sprinkling can and mixing on a smooth cement floor. This material was then placed in callapsible tin cans about one foot in diameter and thoroughly packed in. Both the can proper and the cover were about 18 inches high and both were packed nearly full before placing together. In the first test cans were prepared with the following percentages of moisture:

Corn--50-100-150 and 200%
Cane--25-50-75 and 100%.

The 50 and 100% corn cans were placed in the experimental silo containing corn fodder, about mid-way between the top and bottom and the other six cans were placed in the cane fodder silo.

Some of this same dry material which was prepared for use in the cans was preserved in sacks for future tests.

On May 8th the corn fodder and on May 13th the cane fodder silo was opened and the cans removed.

The corn fodder in the silo was quite wet but badly rotted, due, perhaps, to insufficient pressure to exclude air. The cane fodder on the other hand was quite well preserved and was good feed, and it seems likely that this difference was due to the higher original moisture of the cane being more thoroughly incorporated than was the moisture added to the corn.

The cans were opened and judged as follows. The acidity, estimated as lactic acid, appears in Table 1X.

Table 1X.

Acidity found in contents of cans

Per cent moisture added	Spring '15	Winter '16	Spring'16
CORN			
25		1.8	1.7
50	1.25	1.7	1.5
75			1.5
100	.56	1.5	1.4
150	.50	1.7	
200	.20		
CANE			
0			2.3
25	2.44	2.2	3.3
50	2.12	1.8	3.1
75	2.35	1.2	2.0
100	.41	1.95	
Sample from silo			1.7

Notes on Cans Removed

Cans removed May 8, 1915.

Corn 50% moisture: Somewhat discolored, slightly unpleasant odor. Rather sour to taste, slightly dry, would make only fair feed.

Corn 100% moisture: Darker colored than 50%, more unpleasant odor, only slightly sour, probably wouldn't be eaten, good succulence.

Corn 150% moisture: Badly discolored; flat, spoiled taste; no acid to test; soaked.

Corn 200% moisture: Badly spoiled; rather rotten condition; no acid to taste; watery and worthless.

Second trial, May 22, 1915.

In the spring of 1915 this experiment was repeated in exactly the same manner, except the 200% water added to the corn fodder in the previous test was so plainly too much that it was not repeated. Instead 25% water was added to the material in one can.

The corn fodder preserved from the previous test, although slightly mouldy in spots, was used in this test, but the cane which had been held over was badly moulded so it was discarded and some cane butts, which had lain out in the weather were obtained from the Agronomy Department. These were slightly moulded, quite dry, and the sugar could not be detected in the stalks by the taste. The corn fodder used seemed to be almost air dry.

The water was added and the cans prepared just as in the first test, but they were placed in the experimental silos, containing alfalfa silage mixtures, which were being filled at this time. The cans of corn fodder were put in the silo being filled with alfalfa and molasses and the cans of cane fodder in the silo being filled with alfalfa and rye.

The silos were opened January 1st but were not emptied down to the cans at that time. The corn cans were taken out on February 24th and the cane cans on March 8th. The cans were opened and judged as follows. The acitity, determined as lactic acid, appears in Table IX.

Cans of corn fodder silage removed February 24, 1916.

No. 1--25% moisture.

Very dry; rather mouldy odor; no sour taste; fairly bright in appearance.

No. 2--50% moisture.

Somewhat dry; odor slightly mouldy; no sour taste; slightly discolored.

No. 3--100% moisture.

Moisture quality about right; unpleasant odor of decay; slight sour taste but unpleasant and bitter.

No. 4--150% moisture.

Too wet; very flat, unpleasant taste; no sour taste; very unpleasant.

In a feeding test all of the silage was refused by heifers on a silage and grain ration.

Cans of cane fodder silage removed March 8, 1916.

25% moisture: Slightly musty; too dry; fibers somewhat softened; some stems still almost sweet; odor slightly acid but not unpleasant; unpleasant taste; sour taste not marked; poor feed; fairly bright color; refused by cows.

50% moisture: Somewhat dry; very slight musty smell; fibers fairly soft; odor somewhat better than that of 25%; rather poor feed; refused by cows.

75% moisture: No mustiness; about moist enough; fibers soft; rather pleasant odor; taste not unpleasant but not sour; picked over somewhat when offered to cows.

100% moisture: No mustiness; feeding quality about right; fibers very soft; strong, rather pleasant acid smell and sour taste. Eaten some by cows.

Third trial.

This experiment was repeated for the third time with the cans and for the second time with the silos on February 26, 1916.

The corn fodder used was somewhich had stood in piles about six weeks and then had been loosely piled in the barn lot. It contained 18% air dry moisture.

The cane butts were cut rather green for fodder and had been piled in the barn lot almost immediately in a compact round pile and covered with Sudan hay. When put into the silo they were still very sweet and juicy and were found to contain 62 per cent air dry moisture. About four tons of corn fodder was put into the first silo and about 63 cubic feet, or approximately 50% of water was added in the blower and on surface of full silo. Approximately eight tons of cane fodder were put into the second silo and 30½ cubic feet or 11% water was added.

A third silo was also filled with headed kafir and about 20% water added but it has not been opened as yet.

The method of procedure with the cans was the same as in the previous tests, only this time the 150% water was discontinued in the case of corn and a 75% water substituted. It was found impossible to incorporate 100% water into the cane as it was already very wet, so a can was substituted containing the material with no water added.

All the cans containing corn fodder were put into the silo being filled with corn fodder and all the cans containing cane were put into the silo being filled with cane.

The corn silo was opened May 2, 1916 and the cane May 21, 1916. The corn was found to be too dry and was rather moldy, as there was neither enough water added nor sufficient pressure to exclude the air. It was not a satisfactory feed. The cane fodder silage was found to be in very fine condition and would pass for normal silage anywhere, except for the absence of grain.

The cans were removed from both silos, opened and judged as in the previous tests. The acidity appears in Table IX.

Corn cans removed May 2, 1916.

25%--Too dry; no fermentation; pleasing odor; fibers somewhat softened; no acid to taste; no mould; bright appearing; looked like damp shredded fodder.

50%--Somewhat dry; little fermentation apparent; not a very pleasant odor; fibers quite soft; slight mouldy smell; slight acid taste; bright appearing; pretty good feeding condition.

75%--Slightly dry; some fermentation; fairly pleasant odor; fibers quite soft; no mouldy smell; slight acid taste; bright, good feeding condition.

100%--About the right moisture; some fermentation; good odor; fibers soft enough; no mould; some acid taste; very good feeding condition; dark color.

Cane cans removed May 21, 1916.

No water--Somewhat dry; bright; good acid taste and smell; fibers quite soft; relished by cows.

25% water--Fine feeding condition; bright, very marked acid taste and smell; fibers soft; relished by cows.

50% water--Rather wet; bright; strong acid taste and smell but rather acid; fibers very soft; eaten somewhat.

75% water--Sloppy; dark; acid taste and smell but very acid; refused by cows.

From these data it appears that fermentation and acid production takes place when fodder is ensiloed, much like when the green crop is put into the silo. Satisfactory acid seemed to be produced except in the case of the cane where a very large amount of water was added. Fermentation was also shown by the rise in temperature of the silage. In 1915 resistance bulbs were buried in the silos and the temperatures were taken daily with the electric thermometer for about five weeks. In the corn silo a shallow lead attained a maximum of 156 degrees F on the nineth day and a deep lead a maximum of 106 degrees F on the twenty-fifth day after filling. In the cane silo the shallow lead reached a maximum of 117 degrees F in nine days and the deep lead a maximum of 115 in twelve days after filling. The high temperature (156 degrees F) noted in the corn fodder silo was probably caused by the presence of air, due to poor packing and the fact that the lead was rather near the surface.

The silos in which these temperature observations were made were filled on March 20th and 21st.

The amount of water to add to fodder put into the silo depends to a large extent upon the moisture content of the material which is to be used. Dry corn which has stood in the field will require from 75 to 100% water for the best results. If the corn was piled in a compact pile soon after cutting and protected from the rain it would remain in much better condition and make much better silage. It is difficult to incorporate the moisture again after it is once lost. Also it is very difficult to add sufficient water in the blower and running water on top of the silage is not very satisfactory as water thus added probably tends to follow the least packed places in the silage or the sides of the silo, rather than to be evenly distributed down through the material.

Much better results could probably be obtained in a silo of larger size than the small experimental silos used, as the lack of height and large side friction in proportion to capacity in the experimental silos prevents proper packing and air exclusion.

Cane fodder properly preserved to conserve its moisture requires only about 25% water, while the dry fodder would probably have to have 75% water added.

Both Missouri Station (Ref. 11) and Vermont Station (Ref. 12) suggest the addition of a somewhat larger amount of water than was found best in this experiment.

Summary and Conclusions.

1. The weight of silage depends upon a great many factors, the chief one being the moisture content, which in itself is dependent upon many factors, but normal silage will average from 38 to 39 pounds per cubic foot. Instead of the range in silage weights being from 18 pounds per cubic foot at the top of the silo to 58 pounds per cubic foot at the bottom of a 32 foot silo, as suggested by King, the range is more probable from about 30 pounds at the top to about 48 pounds at the bottom.

2. The increase in weight from top to bottom of the silo is not regular but is rapid near the top, then less and again more rapđd at the bottom.

3. The weight of silage is slightly greater per cubic foot in the center than at the side of the silo.

4. The temperature in a silo rises for the first few days after filling, then gradually declines, the maximum temperature reached generally being from 85 to 105 degrees F. The temperature at the center is less variable than that at the wall, and reaches a higher maximum, but does not reach its maximum till after the maximum has been reached near the wall of the silo. The maximum temperature is reached near the wall of the silo within a week and at the center within two weeks.

5. The kind of material used in the construction of the silo does not seem to materially affect the temperature of the silage.

6. The temperature observed on the surface of silage is not an accurate measure of the temperature within the silo, as surface temperature will generally exceed the temperature within the silo from 40 to 60 degrees F.

7. The moisture content of the silage crop has a direct effect upon the acidity of the silage, the higher the moisture the higher the acidity.

8. Good silage can be made from corn or cane fodder by adding water, the amount added depending upon the dryness of the fodder. Very dry fodder requires from 75 to 100% of water by weight, while cane stacked soon after cutting requires only 25%.

9. The moisture of the crop should be conserved as much as possible as it is difficult to proper incorporate moisture once lost.

10. The water should be added direct to the blower as far as possible as ~~it is difficult to~~ running it on top of the silage is not very satisfactory.