Types and Varieties of Corn for Silage

Yield of Nutrients; Composition; Feeding Value for Milk Production

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CONTENTS

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CORN SILAGE is one of the important roughages fed to dairy cattle in those dairy regions of the United States in which corn is grown successfully. The entire harvestable portion of the corn plant may be preserved as silage and fed with but little waste, thus conserving for feed purposes a much greater proportion of the nutrients than when the grain portion only is used or when the crop is utilized as grain and dry stover. The acre-yield of nutrients in corn harvested for silage is usually fully equal to and in many cases greater than that of other feed crops grown in the same area. Dairymen in general recognize not only this value of corn grown for silage, but also the fact that the feeding of corn silage tends to promote the physiological well-being of cattle, as indicated by their keen appetites, the healthy condition of their hides and hair, the slightly laxative effect it produces, and the general appearance of health that results.

Since the user of the silage must, in most cases, also be the producer, he is interested not only in the feeding value of silage but also in its economical production. For many years the question has been asked, which is the more profitable variety of corn for silage, one which will give a large yield of mature grain, or one which will give a large yield of green forage? An attempt to answer this question was the primary motive for planning the investigation.

The project was undertaken after making a study of experiments conducted at other stations. Several comprehensive studies of the subject have been completed elsewhere and various phases of it have received attention. A general review of the literature,* however, indicated a lack of concordance in results that probably is traceable to the different climatic and soil conditions obtaining in the various investigations. It therefore seemed that any data which would help Illinois dairy farmers choose the most profitable type or variety of corn for silage must of necessity be obtained under conditions existing in the state.

OBJECTS OF EXPERIMENT

The primary objects of this investigation were to compare the value for silage purposes of: (a) large, late varieties of corn not maturing

*See pages 111 to 120.

grain with earlier varieties of corn maturing grain; and (b) prolific types of corn (bearing two or more ears per stalk) with nonprolific types (bearing but one ear per stalk). It was assumed that the best variety of corn for silage is one which combines large yields of dry matter to the acre with good keeping qualities and feeding value as silage.

During the course of the experiment questions arose concerning ways of preserving corn in the silo. Secondary objects of the experiment were therefore to determine: (a) the optimum percentage of dry matter in corn at the time of ensiling; and (b) a method of preventing or reducing the spoilage which normally occurs at the surface of a silo after filling, when the silage is left undisturbed for several weeks or months.

PLAN OF EXPERIMENT

Growing the Corn

Varieties.—The varieties of corn selected for use as standard, or check, varieties in this experiment were Reid Yellow Dent and Leaming, both yellow dent varieties, and Boone County White, a white dent variety. All are commonly grown for grain purposes in that portion of the corn belt having climatic and soil conditions similar to those existing at Urbana.

Some varieties of corn grown in the southern states were used for comparison. As grown in Illinois, they mature later than the check varieties. The southern varieties used were Ardelt, Garrick Prolific, Mexican June, Virginia Horsetooth, and Cocke Prolific. All of these are white dent varieties. Garrick Prolific and Cocke Prolific tend to produce more than one ear to a plant, but the others as a rule produce only one ear.

Seed of the Ardelt and Garrick varieties was furnished thru the courtesy of the Bureau of Plant Industry, U. S. Department of Agriculture. The seed of Mexican June, Cocke Prolific, and Virginia Horsetooth was obtained from dealers in New Orleans, La., Raleigh, N. C., and Norfolk, Va., respectively.

Other varieties used in the comparison were Illinois Two-Ear, Burr-Leaming Hybrid, and Democrat. The first of these is described in Bulletin 294 of this Station as follows:

"Illinois Two-Ear is a yellow corn which produces two ears on 50 to 80 percent of the stalks. It was developed by the Plant Breeding division of this Station by ear-row breeding. It has produced an average of 5.9 bushels an acre more than Reid Yellow Dent during the eight years it has been grown, with odds of 31 to 1 that this difference is significant. Because of its high yielding power, it was hoped that this corn would be useful as a silage or fodder corn, and also for grain production in cases where a machine husker could be used, or for hogging down. The ears are smaller, especially in diameter, than those

produced by the single-ear varieties, but this characteristic may be considered in its favor when being fed to cattle in the ear. However, Illinois Two-Ear possesses the objectionable character of lodging badly before it is sufficiently mature for silage. This greatly increases the labor involved in harvesting, whether for silage, fodder, or grain, and markedly increases the percentage of ears damaged thru their coming in contact with the ground."

The seed of the Illinois Two-Ear corn was furnished thru the courtesy of the Plant Breeding division of this Station. This division also cooperated in the production of the Burr-Leaming Hybrid, a cross between Burr-Leaming and a multiple-cross selection made at this Station. The variety known as Democrat is said to be "practically the same as, if not identical with, Champion White Pearl" (Bulletin 294). The seed of this variety was obtained from a grower at Sparta, Randolph county, Illinois, a section of the state in which "only varieties that possess more than average vigor are able to make a good showing" (Bulletin 294).

The corn known as Reid Yellow Dent (D) was grown from seed unselected for freedom from disease. The seed of the Reid Yellow Dent (A) corn was obtained from the Crop Production division of the Agronomy Department of this Station and had been thoroly tested for freedom from disease and for high germination.

Because the plots were side by side and the corn thus subject to cross-pollination, new supplies of seed were obtained each year from the sources mentioned.

Plots and Their Treatment.—The corn was grown during the six seasons 1923 to 1928 inclusive, on a forty-acre field of the University dairy farm. The same field was used each year. The land was not entirely uniform in topography, but the plots were so arranged that they were fairly comparable. Stable manure was applied to the field during several of the winter seasons, and in the spring of 1927 raw rock phosphate was applied broadcast at the rate of two-thirds ton to the acre. The plots for all varieties except Reid Yellow Dent ranged in size from about three-fourths acre to three acres. This variety was the one commonly used for silage on the farm and so, after plots of the other varieties had been planted, Reid Yellow Dent was planted in the rest of the field.

The plots covered the field solidly; that is, no space was left between adjoining plots other than the distance between the rows, which was 3.5 feet. The plots were marked by stakes set in the first row of each plot.

Planting.—The corn was drilled in rows, the rows being spaced 3.5 feet apart. An attempt was made to space the kernels about 10 inches apart in the row, but it was impossible to maintain this spacing consistently because the size of the kernels of the different varieties

varied.* Thickness of planting in the row was but one of the factors, however, which determined the number of plants in the row at harvest. Other factors were percentage germination, losses during cultivation, suckering, and wind storms which in some seasons broke down many plants.

Cultivation.—Cultivation was carried out in a thoro manner with shovel cultivators. Beginning in 1924 rotary hoes were used before the corn was large enough for the use of the shovel implements, and in place of the usual early cultivation with shovel cultivators. In 1923, 1924, and 1927 hand-hoeing was employed to remove large weeds which had escaped the horse-drawn cultivators. The field at harvest time was relatively free from weeds. Some foxtail was present in several of the seasons, but little of this was included in the harvested crop.

Weather.—Weather conditions varied greatly during the different seasons (Table 1). The early part of the growing season of 1924 was cold and unfavorable for growth. There was evidence during the summer that corn root worms had damaged many plants so that they fell over easily. The corn was in an unusually green condition at time of harvest. The season of 1925 was, on the whole, a hot, dry season, causing early maturing of the corn. A late, rainy spring occurred in 1927, and the rainfall during the growing season was unusually large. In spite of adverse weather conditions planting was accomplished each year during the period May 11 to May 22 (Table 2).

Sampling the Growing Corn

It was planned to sample each variety of corn in the field at regular intervals beginning about August 1. It was not until 1927, however, that the corn stood up well enough to permit the field sampling to be carried to a conclusion.

Taking samples of the growing corn from each of the variety plots at intervals during the latter part of the season, it was believed, would give valuable information regarding earliness of maturity, proportions of ears and stalks, and rapidity at which nutrients develop, thus providing a basis for estimating the best stage of development for harvesting each variety and the comparative values of the different varieties when the growing season was shortened because of early frosts or late seedings.

Samples were taken in 1927 at weekly intervals for ten weeks be-

*The scope of this experiment was not great enough to make possible a study of the effect of variable spacing upon the yield of corn as a silage crop. Undoubtedly variations in spacing do have an effect upon the total yield of dry matter and upon the value of the total silage yield, if evident effects of variations in spacing upon the yields of ears alone is sufficient indication (see reference No. 11, page 120).

TABLE 1.—WEATHER DATA FOR THE YEARS DURING WHICH FIELD TESTS WITH VARIETIES OF CORN WERE CONDUCTED[a]

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year total
Precipitation in inches													
1923	1.57	1.34	5.25	2.96	5.26	3.20	3.26	4.08	2.99	3.78	1.68	5.01	40.38
1924	1.70	1.93	2.74	3.61	2.69	8.68	.86	7.65	2.22	1.36	.83	6.13	41.20
1925	.73	1.28	4.62	1.86	.22	2.28	1.14	3.42	5.69	4.16	2.81	1.19	29.40
1926	1.86	2.98	2.75	4.01	2.34	3.60	4.38	4.01	9.76	4.45	2.46	.93	43.53
1927	1.67	1.22	3.84	6.48	5.01	5.87	6.02	4.79	7.13	3.58	6.77	3.55	55.93
1928	2.18	2.28	1.45	3.16	2.48	4.65	3.69	2.77	3.65	2.34	1.88	2.53	33.06
Mean monthly temperatures (°F.)													
1923				38.4	49.0	62.1	65.1	62.0	55.9	41.4			
1924				41.6	45.2	58.8	60.9	62.9	51.0	47.1			
1925				45.1	45.5	63.7	64.4	62.4	62.3	38.0			
1926				34.8	52.3	56.4	64.5	66.3	58.6	44.8			
1927				42.8	51.0	56.7	63.0	57.3	59.6	47.7			
1928				47.5	61.0	67.0	76.8	76.0	62.7	57.7			
Mean relative humidity (percent)													
1923				65.1	64.9	67.5	65.1	75.0	77.8	68.3			
1924				64.1	66.8	74.6	63.1	73.6	74.0	62.9			
1925				60.8	52.7	68.5	61.8	75.9	69.3	80.3			
1926				73.9	60.4	61.6	61.3	75.6	83.0	76.1			
1927				72.5	72.9	68.4	64.4	69.2	71.5	66.5			
1928				70.1	56.9	72.5	68.7	73.0	66.8	70.9			

[a]Data furnished thru courtesy of Department of Agronomy.

ginning August 6. One interval, however, was extended to nine days (September 24 to October 3) because of storms.

Two rows in each of six variety plots were selected and marked by stakes. These rows were not harvested when the remainder of the plot was cut for silage, but were left standing for the purpose of field sampling. The rows were about eighty rods in length. One man counted the plants in the row and cut every one-hundredth plant about six inches above the ground. The cut plants were handed to an attendant who carried them to the end of the row. There the plants were tied into a bundle and weighed at once. On successive sampling dates the place at which the first plant in the row was taken for the sample was advanced ten plants so that there would be a uniform distribution of sampling points.

As soon as selection and weighing were completed in the field, the samples were taken to the barn where counts were made of plants, tassels, and ears. The samples were then reweighed. The entire ears, including husks, were separated and weighed. Stalks and ears separately were cut into short lengths by a power cutter, reduced in amount (when necessary) by quartering, and subsamples taken for analysis.

TABLE 2.—LENGTH OF GROWING PERIOD OF VARIETIES OF CORN HARVESTED FOR SILAGE

Variety of corn	1923			1924			1925			1926			1927		
	Planted	Harvested	Growing period	Planted	Harvested	Growing period	Planted	Harvested	Growing period	Planted	Harvested	Growing period	Planted	Harvested	Growing period
Grain varieties															
	May	*Sept.*	*days*	*May*	*Sept.*	*days*	*May*	*Sept.*	*days*	*May*	*Sept.*	*days*	*May*	*Sept.*	*days*
Reid Yellow Dent (D)	19	22	126	13	19	129	13	19, 21	130	13	10, 11	120	17	20	126
Reid Yellow Dent (A)	..	..	...	..	..	...	13	21, 22	131	13	13, 14	123	17	20	126
Leaming	21	24	126	15	23, 24, 25	132	12	22	133	13	16	126	17	21	127
Boone County White	19	27	131	14	23	132	12	24	135	12	17	128	21	21	123
Democrat	..	..	...	14	23	132	12	25	136	12	17	128	..	..	...
Illinois Two-Ear	21	7, 8	109	14	17	126	12	23	134	13	7, 8, 10	118	16	22	129
Southern varieties															
Ardelt	21	24	126	13	17	127	..	.....	...	..	..	...	..	..	...
Garrick Prolific	21	24	126	13	17	127	..	.....	...	..	..	...	..	..	...
Cocke Prolific	21	21	123	14	18	127	11	23, 24	135	12	20	131	16	22, 23	129
Mexican June	21	23	125	13	17	127	11	23	135	12	..	...	16	22	129
Virginia Horsetooth	22	23	124	14	18, 19	127	12	23, 24, 25	135	12	21	132	16	22, 23	129

Harvesting the Crop

The corn was harvested for silage in September of each year. The time of harvest was determined to a large extent by the maturity of the corn and probability of frosts. The dates of harvesting were such, however, that the length of the growing periods during different years covered by the experiment were not widely different (Table 2).

FIG. 1.—AN EXPERIMENTAL CORN PLOT AND THE WOODEN SILOS USED IN PART OF THE STUDY

Both grain and southern varieties produced stalks 10 to 12 feet and more high. Some of the ears were 6 to 8 feet above the ground, as indicated by the man at the left, who is holding his hand at the base of an ear. The wooden silos in the foreground of the upper picture were used for ensiling the three varieties of corn used in the feeding trials (before the trials began, they were provided with roofs). The lower picture at the right shows the corn being hauled from the field.

Before harvesting, borders were removed from the plots by hand-cutting. Harvesting was done in most cases by means of a tractor-drawn corn binder which bound the plants in bundles and dropped them on the ground. In a few seasons it was necessary to cut some of

the plots by hand on account of the lodging of the corn. Six to eight teams and fifteen to eighteen men were employed in harvesting and ensiling the corn. It was necessary to have several acres of corn cut in advance ready for the haulers. This meant that at times some of the corn remained in the field for a half day or more after cutting.

Three varieties were selected for use in feeding trials. Reid Yellow Dent was selected as a representative of a maturing grain variety, Virginia Horsetooth as a nonmaturing single ear variety, and Cocke Prolific as a nonmaturing prolific variety. Corn from these varieties was ensiled separately in wood stave silos 10 by 24 feet in size.

Sampling the Crop at Harvest

The loads of corn from each plot were weighed. As the corn was blown into the silo, samples were taken at random from time to time and placed in a covered 8-gallon milk can which was suspended by a rope in such a manner that it could be raised readily as the silo was being filled. The volume of the samples from the different plots of corn ranged from 8 to 24 or more gallons. The cut corn comprizing a single sample was thoroly mixed on a clean floor and reduced in quantity by quartering until two diagonal quarters furnished the desired amount which was usually about 1½ gallons. The subsample was weighed at once and preserved for analysis.

Analyzing Samples of Silage and Other Feed

The samples of green corn taken during the growing season and at harvest and the corn silage samples taken during the progress of the digestion and the feeding trials were first placed in shallow pans and dried on the steam bath, after which they were covered with wire screen and allowed to stand in the laboratory several days in order to come to air-dry condition.

Samples of grain mixtures fed during the feeding trials were taken by means of a double-tube brass grain trier. Three or four trierfuls comprized a sample. Samples of each new batch of grain as ground and mixed (usually at one-week intervals) were taken. The samples representing one feeding period were thoroly mixed and composited for analysis.

The hay used in the feeding trials was selected from a supply of baled hay. At regular intervals a few bales were selected at random and a core taken centrally lengthwise thru each bale while still unbroken.* The weight of the cores, which were combined for the samples, was about a pound.

Silage fed during feeding trials was sampled by taking a core of

*The device used for sampling hay and silage is described as a "roughage sampler," by W. L. Gaines, Jour. Ind. and Eng. Chem. **16**, 386. 1924.

FIG. 2.—THREE VIEWS OF THE OUTFIT USED FOR CUTTING AND BINDING THE CORN ON THE EXPERIMENTAL PLOTS

The device used on the tractor to pick up lodged stalks is shown more clearly in the two lower pictures. The use of this device greatly reduced losses where the corn was badly lodged. (Improvements developed after this study are shown in Fig. 7, page 110.)

silage to a depth of 24 to 30 inches at several points on the surface of the silage in the silo. These portions were united for the silage sample, weighed, and brought to air-dry condition as described above.

All samples were ground to pass thru a 1-mm. sieve, thoroly mixed, and preserved in jars fitted with glass tops and rubber rings. The methods of analysis described in the Proceedings of the Association of Official Agricultural Chemists were followed.

RESULTS OBTAINED IN FIELD TESTS

The field tests gave valuable information concerning the yield of nutrients, earliness of maturity, ease of harvest, and quality of the nutrients of the different varieties. Feeding trials comparing the values of silage from the different varieties would have been quite unsatisfactory as the only criteria for judging the suitability of these varieties for silage purposes.

Yields of Forage and Nutrients to the Acre

The southern varieties, Ardelt, Garrick Prolific, Cocke Prolific, Mexican June, and Virginia Horsetooth, yielded large amounts of green corn, the crops weighing from 9 to 16 tons to the acre (Table 3). The grain varieties, Reid Yellow Dent, Leaming, Boone County White, Democrat, and Illinois Two-Ear, also yielded as much as 16 tons to the acre of green corn but some of the plots yielded as little as 7 tons to the acre. Owing to the wide variability in yields during the different seasons and between different varieties, a great deal of reliance cannot be placed on averages for the two types of varieties. However, if the average yields are thought worthy of consideration, they may be computed from Table 3. It will be found that the 18 plots of the southern varieties gave a yield of about 11.5 tons of silage corn to the acre, and the 26 plots of the grain varieties slightly over 10 tons to the acre.

Upon calculating the yields of nutrients in the crop it was found that the southern varieties had a higher water content than the grain varieties. Upon calculating the yields of dry matter from all plots, it was found that the 18 plots of southern corn yielded 6,270 pounds of dry matter to the acre, while the 26 plots of the grain varieties yielded 6,880 pounds, about 600 pounds more. The averages indicate, therefore, that even tho the yields in weight of fresh matter at time of harvesting were somewhat greater for the southern varieties, the yields in dry matter were slightly greater for the grain varieties.

Unless it can be demonstrated that corn with a high water content produces silage which has better keeping or feeding qualities than corn of lower water content—advantages not found in the feeding trials reported here—it is reasonable to assume that the presence of a large amount of water in corn at time of harvest is a handicap. The fresh weight of the southern varieties was about 1.5 tons greater per acre

TABLE 3.—YIELDS PER ACRE OF FRESH AND DRY MATTER IN DIFFERENT VARIETIES OF CORN AS ENSILED, AND YIELDS OF NUTRIENTS

(Pounds per acre)

Variety	Year	Yield of crop as ensiled	Yield of nutrients					
			Dry matter	Ash	Crude protein	Crude fiber	N-free extract	Ether extract
Grain varieties								
Reid Yellow Dent (D)[a]	1923	23 240	7 613	462	616	1 631	4 741	163
	1924	20 310	5 583	292	431	1 359	3 387	114
	1925	13 553	5 942	313	520	1 185	3 841	83
	1926	16 992	5 189	591	462	1 263	2 799	75
	1927	21 268	7 038	338	498	1 636	4 417	149
Reid Yellow Dent (A)[b]	1925	16 461	6 907	365	617	1 376	4 489	59
	1926	24 193	8 180	593	682	1 628	5 100	177
	1927	19 109	6 703	319	431	1 505	4 298	151
	1928	19 250	6 628	354	495	1 425	4 200	154
Leaming	1923	14 180	6 696	391	620	1 401	4 124	160
	1924	20 772	7 027	438	688	1 273	4 478	150
	1925	15 653	6 519	379	570	1 190	4 272	110
	1926	18 354	6 350	560	512	1 380	3 775	123
	1927	18 321	6 244	319	460	1 442	3 813	211
Boone County White	1923	22 200	7 681	611	684	1 709	4 513	164
	1924	24 727	7 841	450	648	1 763	4 854	126
	1925	15 096	6 772	403	583	1 431	4 284	71
	1926	20 481	7 109	627	582	1 432	4 321	147
	1927	26 009	7 844	429	554	1 969	4 754	138
Democrat	1924	15 821	5 362	312	457	1 180	3 326	87
	1925	14 550	5 466	370	477	1 253	3 264	102
	1926	16 645	5 862	380	444	1 240	3 684	115
Illinois Two-Ear	1923	30 660	8 548	665	883	2 119	4 758	123
	1924	32 755	7 907	367	632	1 897	4 825	187
	1925	16 179	6 616	413	592	1 328	4 203	79
	1926	24 953	8 477	1 158	629	2 026	4 526	137
	1927	23 122	7 394	333	492	1 649	4 738	183
	1928	17 780	5 160	318	393	1 213	3 101	135
Burr-Leaming Hybrid	1928	16 170	5 126	264	454	960	3 315	133
Southern varieties								
Ardelt	1923	23 740	9 249	499	824	2 137	5 615	176
	1924	18 474	4 153	188	292	1 434	2 182	55
Garrick Prolific	1923	22 900	6 577	348	540	1 921	3 588	181
	1924	24 123	5 080	232	367	1 595	2 820	68
Cocke Prolific	1923	22 000	6 651	370	561	1 679	3 938	103
	1924	24 801	5 032	303	474	1 347	2 845	65
	1925	24 317	7 161	528	635	1 797	4 131	68
	1926	20 386	6 568	481	489	1 470	3 988	141
	1927	24 511	6 022	397	505	1 753	3 275	92
Mexican June	1923	20 740	6 620	322	595	1 659	3 934	112
	1924	23 649	5 059	331	497	1 551	2 592	88
	1925	19 220	6 052	429	536	1 390	3 611	86
	1926			(Germination failure)				
	1927	23 010	5 840	318	426	1 588	3 426	83
Virginia Horsetooth	1923	32 240	9 907	503	835	2 196	6 187	184
	1924	23 649	5 938	371	499	1 537	3 436	95
	1925	21 646	5 944	416	565	1 442	3 444	78
	1926	18 345	4 434	356	356	1 141	2 521	61
	1927	25 444	6 572	382	524	1 616	3 923	127

[a]Dairy Department seed. [b]Agronomy Department seed.

than that of the grain varieties, a difference of about one load to the acre. The extra handling and hauling in order to get the same dry-matter yield is an item of labor expense worth considering.

An inspection of the yields of dry matter shows that there was a greater variation in yields from season to season among the southern varieties than among the grain varieties. The highest yields of dry matter in Ardelt and Virginia Horsetooth varieties were more than twice as great as the lowest yields of the same varieties. No such extreme variations were found among the grain varieties.

Just as the yields of dry matter in the grain varieties varied less from year to year and averaged more in amount than the yields of dry matter in the southern varieties, so the yields of protein and nitrogen-free extract appear to be greater and less variable from season to season in the grain varieties than in the southern varieties.

Even tho there may be some question regarding the reliability of averages in computing the relative yields of the southern and the grain varieties, there is no evidence from the annual yields of the various plots that the southern varieties were superior in any way to the grain varieties.

It is interesting to note that the yields of protein on many of the plots were upwards of 500 pounds to the acre, yields which compare favorably with the protein yield from a 2-ton crop of legume hay. The protein in the silage made from three of the corn varieties was found to be lower in digestibility, however, than the protein in legume hay; hence a comparison based on the amounts of digestible protein would be less favorable to silage than a comparison based on total amounts of protein.

The sampling of the corn in the field at weekly intervals gave an additional means of computing acre-yields. The fresh-matter yields during the growing season, illustrated in Fig. 3, do not tally closely with the fresh-matter yields as harvested for silage. This may be explained in part by the fact that in harvesting the corn for the silo some corn remained in the field for half a day or more after it was cut and as a consequence had lost some moisture before it was weighed. In all cases the fresh weights of the crop, as calculated from the samples of the standing corn on September 17 and September 24, were greater than the weights of the crop harvested for silage September 20 to 23 inclusive.

An interesting feature illustrated in Fig. 3 is that the yields of fresh matter in the grain varieties of corn had reached their maximum weight by August 20, and the yields in the other varieties not until one to three weeks later. The weight of the ears, however, continued to increase for several weeks after the total weight of the crop on the fresh basis had reached its maximum. This characteristic of the corn crop to attain its maximum weight of fresh matter several weeks

before it reaches its maximum yield of dry matter has been noted in several of the early as well as in more recent investigations. (See, for example, Ladd[63*] and Ince.[46*])

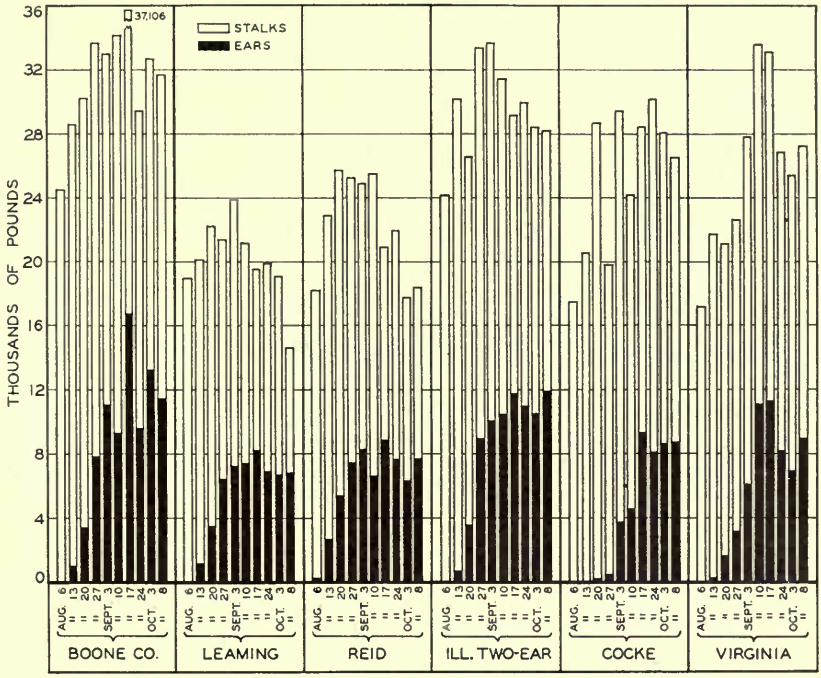

FIG. 3.—FIELD WEIGHTS OF CORN GROWN FOR SILAGE PURPOSES, AT DIFFERENT DATES

Samples of the six varieties indicated above, taken at weekly intervals during the latter part of the season, showed that the maximum field weight of the harvestable crop was reached late in August or early in September. The ears did not reach their maximum until shortly after the total harvestible crop had reached its maximum. A very striking increase occurred in the weight of the ears during the four weeks following August 13. The irregularities shown in the weights of the crop from week to week are to be attributed to the method of sampling rather than to actual irregularities of growth.

The yields of air-dry matter in six varieties of corn (Fig. 4) show that there was a very rapid development of dry matter in the crop during August and September. The dry matter in the stalks had apparently reached its maximum by September 3, but the dry matter in the ears continued to increase in amount up to October 3. Harvesting the crop for silage on August 6, the first sampling date, would have resulted in yields only one-third to one-half as great as those of the

*These figures refer to literature citations, pages 120 to 124.

fully mature crop. Harvesting early in September also would have meant the sacrifice of a large part of the feeding value of the crop. This loss would have been chiefly that of ears, the portion of the crop most valuable for feeding.

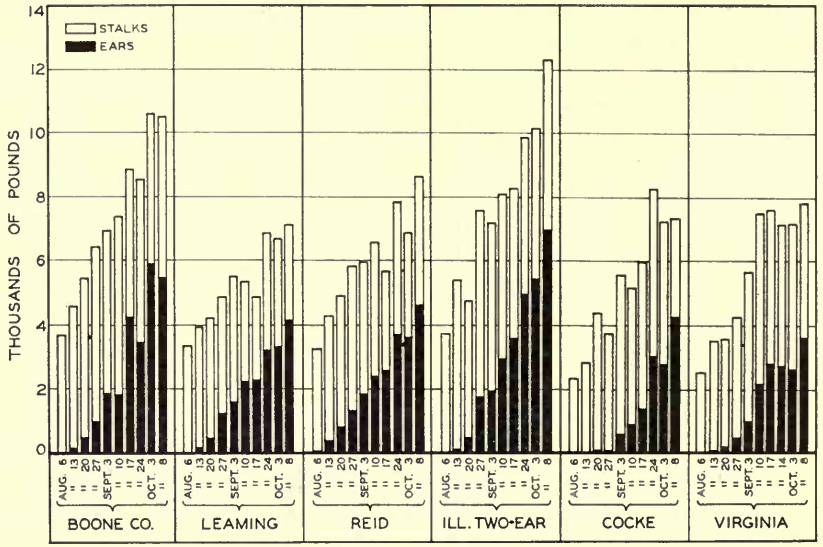

FIG. 4.—YIELDS OF AIR-DRY MATTER IN CORN GROWN FOR SILAGE, AT DIFFERENT DATES

Unlike the field weight of the crop (Fig. 3), the amount of air-dry matter in the harvestable crop continued to increase at a fairly uniform rate thruout the sampling period. To have harvested the crop when it reached its maximum fresh weight would therefore have meant the sacrifice of a large portion of its feeding value. Cocke and Virginia showed a slower development of dry matter in the ears than did the grain varieties, and their total maximum yield of dry matter was less.

The yields of nutrients were undoubtedly affected by thickness of stand. An attempt was made to have the stands of corn uniform for the different varieties, but counts of plants in the field showed that there was considerable variation in the number of plants to the row (Table 4). Differences in viability and vigor of the seed used, variations in spacing by the planter, and the effects of storms, were factors which undoubtedly affected the thickness of the stands. Observation seemed to indicate that when cold weather followed planting, the southern varieties germinated more slowly and made a slower growth during the first one or two weeks than did the grain varieties.

In addition to the factors mentioned another very important factor

TABLE 4.—THICKNESS OF STAND OF CORN AS SHOWN BY DISTANCE OF HARVESTABLE PLANTS IN ROW AND NUMBER OF PLANTS AND EARS TO THE ACRE, SEASON OF 1927

Variety	Distance between plants in row, Sept. 3	Number of plants to the acre, Sept. 3	Number of ears to the acre[a]
	inches		
Reid Yellow Dent	14.80	10 090	9 080
Leaming	15.84	9 430	8 690
Boone County White	15.65	9 540	10 070
Illinois Two-Ear	10.75	13 890	20 140
Cocke Prolific	16.96	8 810	10 550
Virginia Horsetooth	21.28	7 020	8 620

[a]Calculated from plants comprizing samples taken for analysis on September 3, 10, 17, 24, and October 3.

affecting the stand of corn was the development of suckers. The prolific varieties had a greater tendency to produce suckers than the single-ear varieties. Counts of the plants in connection with field sampling in 1923 and 1927 showed that the Illinois Two-Ear variety had the most plants to the acre. In making these counts no effort was made to distinguish between suckers and original stalks, a sucker large enough to be harvested for silage being counted as a plant.

Comparative Value of the Nutrients

Not only is a large yield of nutrients to the acre an important characteristic of a variety of corn selected for silage purposes, but the quality of the nutrients is also very important. The field studies gave some valuable information on this point.

Many investigations of the nutritive value of the corn plant have shown that the nutrients in the grain are more valuable, pound for pound, than those in the stalk. The 1927 field samples of six varieties secured at a time when it was supposed that the corn crop had reached approximately its maximum development, showed important differences

TABLE 5.—PROPORTION OF AIR-DRY MATTER OF CORN CROP FOUND IN EARS
(Calculated from average of air-dry weights on September 17 and 24 and October 3, 1927)

Variety of corn	Yields of air-dry matter in—			Proportion of air-dry matter of crop in ears
	Ears	Stalks	Total crop	
	lbs.	*lbs.*	*lbs.*	*perct.*
Reid Yellow Dent	3 291	3 510	6 801	48.4
Leaming	2 920	3 248	6 168	47.3
Boone County White	4 556	4 758	9 314	48.9
Illinois Two-Ear	4 672	4 744	9 416	49.6
Cocke Prolific	2 411	4 758	7 169	33.6
Virginia Horsetooth	2 703	4 600	7 303	37.0

TABLE 6.—PROPORTIONS OF CRUDE FIBER IN CORN AS ENSILED, CROP YEARS 1923-1927

Variety of corn	1923		1924		1925		1926		1927	
	Crude fiber in dry matter	Relative amounts of crude fiber[a]	Crude fiber in dry matter	Relative amounts of crude fiber[a]	Crude fiber in dry matter	Relative amounts of crude fiber[a]	Crude fiber in dry matter	Relative amounts of crude fiber[a]	Crude fiber in dry matter	Relative amounts of crude fiber[a]
	perct.	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*
Reid Yellow Dent (D)	21.43	90.04	24.32	93.47	19.94	92.23	24.33	108.57	23.23	93.41
Reid Yellow Dent (A)	.....	.....	.....	.....	19.93	92.18	19.92	88.89	22.46	90.31
Leaming	20.91	87.86	18.14	69.72	18.26	84.46	21.74	97.01	23.10	92.88
Boone County White	22.26	93.53	22.49	86.43	21.12	97.69	20.15	89.92	25.11	100.97
Democrat	.....	.....	22.02	84.63	22.93	106.06	21.14	94.33	.....	.....
Illinois Two-Ear	24.77	104.08	24.00	92.24	20.09	92.92	23.90	106.65	22.28	89.59
Ardelt	23.16	97.31	34.54	132.74	.....	.....	.....	.....	.....	.....
Garrick Prolific	29.19	122.65	31.37	120.56	.....	.....	.....	.....	.....	.....
Cocke Prolific	25.24	106.05	26.78	102.92	25.09	116.05	22.39	99.91	29.25	117.61
Mexican June	25.05	105.25	30.68	117.91	22.96	106.20	.....	.....	27.20	109.37
Virginia Horsetooth	22.18	93.19	25.88	99.46	24.26	112.21	25.73	114.81	26.33	105.87

[a]Based on average of all samples as 100 percent.

in quality of nutrients between the southern varieties and the grain varieties (Table 5). In Cocke and Virginia the air-dry matter in the ears formed 33.6 percent and 37 percent, respectively, of the air-dry matter of the crop, while in the four grain varieties analyzed it formed 47 percent or more.

Further evidence of the differences in the quality of the nutrients in the corn varieties is found in a comparison of their fiber contents at the time of ensiling (Table 6). Comparisons are based on moisture-free samples. In 1924, for example, the fiber in the different varieties formed from 18.14 percent to 34.54 percent of the dry matter. Taking the average of all varieties as 100, the fiber in the southern varieties in 1924 ranged from 99.46 percent to 132.74 percent of the average, while in the grain varieties the fiber content ranged from 69.72 percent to 93.47 percent. Altho there were variations from year to year, the data show a higher average fiber content in the southern varieties.

Presumably the differences in fiber content indicate to a considerable extent differences in the proportions of ears. Corn grain contains about 2 percent of fiber while the stalks contain about 30 percent. It is evident, therefore, that the lower fiber content of the grain varieties was caused by a higher proportion of grain. Thus the results shown in Table 6 confirm those shown in Table 5.

Earliness of Maturity

One of the qualifications which makes a variety of corn desirable for silage purposes is ability to yield a large amount of nutrients before the advent of killing frosts. In central and northern Illinois this is an especially important consideration (Table 7).

That the southern varieties when grown in the latitude of Urbana require a longer period for development than the grain varieties grown in the same latitude was brought out in the field studies of 1927. It is shown in Table 8 that more than three-fourths of the plants of Reid and Leaming corn were showing tassels on August 6, while there were no tassels visible on the Cocke and Virginia varieties on that date. As judged by the development of tassels during the season of 1927, the earliest maturing variety was Leaming, followed in order by Reid, Illinois Two-Ear, Boone County White, Virginia, and Cocke Prolific.

Another indication of earliness of maturity was the development of ears (Table 9). The Reid and Leaming varieties were the first to develop ears, while Cocke was the last. Because several varieties produced more than one ear to a stalk, the varieties cannot be ranked in earliness accurately on the basis of ear development.

In some seasons the grain of the southern varieties reached the stage of being well dented, while in others it was in the milk stage at the time of ensiling the corn. The grain varieties, while not always

TABLE 7.—GROWING SEASON AT URBANA, 1911 TO 1930 INCLUSIVE[a]

	Last killing frost in spring	First killing frost in fall	Growing season		Last killing frost in spring	First killing frost in fall	Growing season
			days				*days*
1911.....	May 10	Oct. 24	167	1921...	Apr. 18	Nov. 10	206
1912.....	Apr. 19	Oct. 24	188	1922...	Apr. 20	Oct. 17	180
1913.....	Apr. 15	Oct. 21	189	1923...	May 10	Sept. 14	127
1914.....	Apr. 21	Oct. 27	189	1924...	Apr. 11	Oct. 23	185
1915.....	Apr. 13	Oct. 6	176	1925...	May 25	Oct. 10	138
1916.....	Apr. 10	Sept. 16	159	1926...	May 4	Oct. 27	176
1917.....	Apr. 15	Oct. 6	174	1927...	Apr. 24	Nov. 6	196
1918.....	May 1	Nov. 2	185	1928...	Apr. 28	Sept. 24	149
1919.....	Apr. 26	Oct. 17	174	1929...	May 2	Oct. 25	176
1920.....	Apr. 14	Oct. 29	198	1930...	Apr. 26	Oct. 20	177
				Average	Apr. 25	Oct. 17	175

[a]Data furnished thru courtesy of Department of Agronomy.

TABLE 8.—EARLINESS OF MATURITY OF CORN VARIETIES AS SHOWN BY DEVELOPMENT OF TASSELS DURING SEASON OF 1927

Variety of corn	Proportion of stalks showing tassels				
	Aug. 6	Aug. 13	Aug. 20	Aug. 27	Sept. 3
	perct.	*perct.*	*perct.*	*perct.*	*perct.*
Reid Yellow Dent.....	79	100	100	100	100
Leaming.....	88	100	100	100	100
Boone County White.....	44	72	94	100	100
Illinois Two-Ear.....	15	75	100	95[a]	100
Cocke Prolific.....	0	0	56	50[a]	95
Virginia Horsetooth.....	0	67	75	100	100

[a]These two calculations are evidently too low, or the ones for the preceding week too high; results which are referable to the method of compiling the data. The calculations were made from the corn plants harvested for analysis.

TABLE 9.—EARLINESS OF MATURING OF CORN VARIETIES AS SHOWN BY DEVELOPMENT OF EARS[a]

Date of sampling	Number of ears on 100 plants					
	Boone County	Leaming	Reid	Two-Ear	Cocke	Virginia
August 6.....	0	6	11	0	0	0
August 13.....	17	33	63	25	0	17
August 20.....	78	76	89	80	6	83
August 27.....	141	88	111	160	13	83
September 3.....	133	117	100	158	100	121

[a]Calculated from plants comprizing weekly samples taken for analysis.

fully dented at time of harvest, were, as a rule, farther advanced in development than the southern varieties.

PRESERVING CORN IN THE SILO

One of the problems in the production of silage is the determination of the optimum stage of development of the corn crop for harvesting. It is a matter of common experience that corn in a very dry condition at the time of ensiling is not well preserved; molding is likely to occur. This condition can be prevented to some extent by the addition of water, but there is often difficulty in adding a sufficient quantity and in having it evenly distributed over the corn.

The varieties of corn differed greatly in their contents of dry matter at the time of ensiling (Table 10). Each variety also showed quite a wide variation in its dry-matter content from year to year. A part of the variation is attributable to differences in the stage of development at harvest time and a part to differences in periods of time the corn was exposed to drying after being cut and before being ensiled.

Optimum Dry-Matter Content

Observations made at the time of filling silos and upon removal of the silage for feeding indicated that whenever the dry-matter content of the corn put into the silo was 40 percent or more there was difficulty in securing good silage. Even tho the corn was thoroly tramped and water added, the corn did not keep as well as corn which had a lower content of dry matter. Moldy spots were found thruout the silage, and the silage removed underwent fermentation and spoiled more quickly

TABLE 10.—PERCENTAGE OF DRY MATTER IN CORN AS ENSILED

Variety of corn	Dry matter in corn when ensiled				
	1923	1924	1925	1926	1927
	perct.	*perct.*	*perct.*	*perct.*	*perct.*
Reid Yellow Dent (D)[a]	32.8	27.5	43.8	30.5	33.1
Reid Yellow Dent (A)[b]	....	....	42.0	33.8	35.1
Leaming	47.2	33.8	41.7	34.6	34.1
Boone County White	34.6	31.7	44.9	34.7	30.2
Democrat	....	33.9	37.6	35.2	....
Illinois Two-Ear	27.9	24.1	40.9	34.0	32.0
Ardelt	39.0	22.5	....	....	....
Garrick Prolific	28.7	21.1	....	....	....
Cocke Prolific	30.2	20.3	29.5	32.2	24.6
Mexican June	31.9	21.4	31.5	....	25.4
Virginia Horsetooth	30.7	25.1	27.5	24.2	26.1
Average of grain varieties	35.6	30.2	41.8	33.8	32.9
Average of southern varieties	32.1	22.1	29.5	28.2	25.4

[a]Dairy Department seed. [b]Agronomy Department seed.

than the silage made from corn of higher moisture content. The silage exposed by the removal of silage for feeding showed evidences of rapid deterioration.

With respect to palatability, it was found in the digestion experiments with sheep (page 94) that the Reid silage, which contained 27 percent dry matter when it was fed, was eaten more readily than either Virginia, which contained 22 percent of dry matter, or Cocke, which contained 19 percent of dry matter. The Cocke silage was distinctly unpalatable, and it was very difficult to obtain a uniform consumption of it.

Considering both keeping qualities and palatability, the most satisfactory stage of development at which to ensile corn proved to be when it has a dry-matter content of about 30 percent.

Rapid Method of Determining Dry-Matter Content.—The Association of Official Agricultural Chemists prescribes that dry-matter content be determined first by bringing the sample of green material to air-dry condition at a moderate temperature (below 100° C.), and then grinding, and drying to constant weight at 100° C. This requires from 24 to 48 hours as a minimum. However, since the dry-matter content of rapidly maturing corn may change considerably even in one day, it was believed that a method which would give the approximate dry-matter content of the crop within a few hours would usually be more desirable for determining the best stage for harvest.

A portable oven was designed which makes it possible to determine with approximate accuracy the percentage of dry matter in green corn within four or five hours (Fig. 5.) Several respresentative stalks of corn are cut into short lengths and approximately a pound sample placed in one of the trays. Each tray consists of a shallow bottom pan and two shallow wire-mesh nested baskets. The sample is distributed in these three containers, thus allowing free access of air. Heat is furnished by a gas burner placed at the lower end of the stack. A gasoline camp stove has also been used successfully as a means of supplying heat. The temperature maintained ranges from 105° C. to 120° C. The higher temperature is used at first when the sample is high in moisture and is gradually reduced as the material dries in order to prevent burning. The arrangement is such that a strong current of hot air passes thru and around the samples, thus causing rapid drying. The results are of sufficient accuracy to be of great value in determining the proper time for ensiling corn and in giving a basis for calculating the amounts of water which should be added to overripe corn as it is being ensiled. The method has been found useful also in drying orts from hay feeding trials. An advantage of this type of oven is that it is simple and requires no electric fan for creating an air current thru it nor other expensive apparatus.

Approximate dry-matter determinations were also made satisfac-

torily by spreading samples of cut corn in shallow baking pans lined with paper and drying them in the oven of a kitchen range. In making determinations in this way care must be taken that the temperature does not become high enough to scorch the paper.

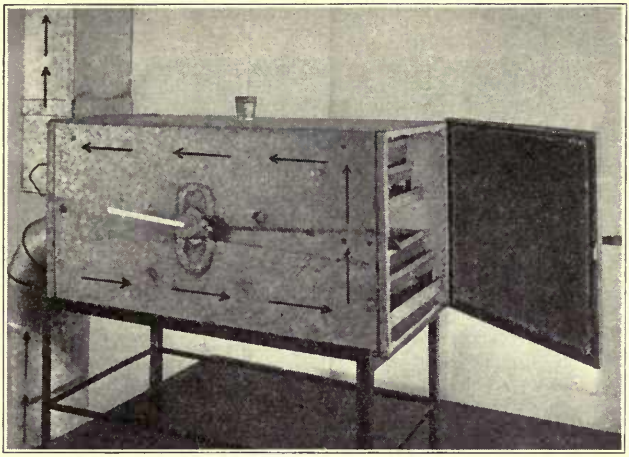

FIG. 5.—OVEN DEVISED FOR RAPID DRYING OF CORN SAMPLES

The oven has two compartments, each containing a removable tray. The trays consist of a bottom pan and two wire-mesh baskets. Samples placed in the baskets are thoroly exposed to the currents of warm air passing thru the oven. The direction of the air currents is shown by the arrows. A stovepipe might well be substituted for the stacks used.

Preservation of Silage at Exposed Surface

Extensive spoilage of silage occurred in silos which were not opened for feeding until several months after filling. This meant not only that much feed was lost but that a large amount of labor had to be employed in removing the spoiled silage. Experiments were undertaken with the object of finding a practicable method for reducing such losses.

The silos used in the experiments were a group of woodstave silos, each 10 by 24 feet in size; a group of hollow tile silos, 14 by 40 and 16 by 40 feet; and three small silos, each 4 by 10 feet in size and mounted on trucks for convenience in weighing (Fig. 6). These last were simply wooden tanks with no side openings. Fifteen cylindrical metal cans approximately 9 by 30 inches in size were also employed.

The small wood silos and the metal cans were placed inside the barn; the other silos were individual outdoor structures provided with roofs. The small silos and cans were filled from a supply of corn delivered onto a wagon from the silo filler. Each small silo in turn was placed on a scale and was filled by means of baskets handed up

from the wagon. The corn was leveled and tramped during filling. The cans were placed on the wagon for filling. Samples of the corn were taken at random thruout the filling process. Coverings were applied at once upon completion of filling.

Use of Chlorin Solutions.—The metal cans were filled September 15, 1928, from a uniform supply of cut corn. The corn was thoroly

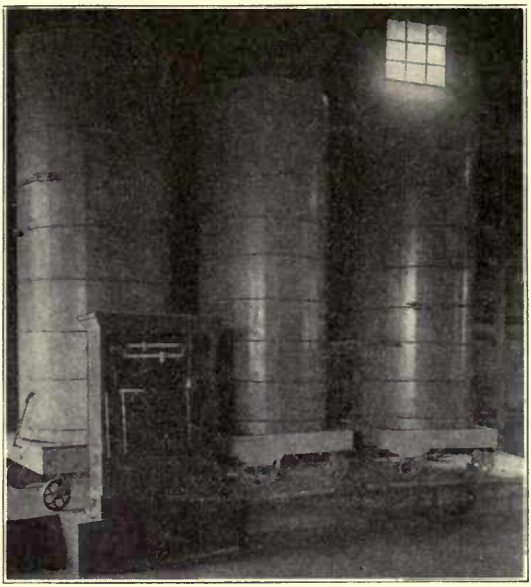

FIG. 6.—MOUNTED SILOS USED FOR SURFACE-PRESERVATION STUDIES

In order to determine the losses that occur in silage under different methods of surface preservation, these silos with their contents were weighed at frequent intervals. Each held about 1,500 pounds of silage.

tamped in the cans, from 41 to 48 pounds being placed in each. The surface of the silage in five of the cans was treated at intervals of 24 hours for 10 days with a solution of Santamine, a chlorine disinfecting agent commonly used in cleaning milk utensils. From .25 to 2 grams of Santamine in 125 cc. of water was applied per square foot of surface at each treatment. Five other cans of silage were treated in the same manner except that treatments were made every 48 hours for 20 days. Two others were given applications of .5 to 1 gram of Santamine in 250 cc. of water per square foot daily for 10 days.

When the treatments of disinfecting solution were given each group of cans of silage, one can was also treated with an equal amount of distilled water. Two cans were given no treatment at all.

The silage was removed on December 14, weighed, and samples

taken for analysis. The amounts of spoiled silage ranged from 5.4 pounds to 6.4 pounds per can, or from 12 to 15 percent of the silage recovered. Altho the appearance of the silage during the period of treatments seemed to indicate a beneficial effect of the chlorin solution, there was no evidence of prevention of spoilage when the cans were opened three months after filling.

Samples taken from the cans at the time of emptying were examined bacteriologically thru the assistance of Dr. M. J. Prucha of the division of Dairy Bacteriology. Three samples were taken from each can. One sample (*A*) was taken from the surface layers and consisted of spoiled silage; another sample (*B*) was secured at the juncture of the spoiled and good silage; and another sample (*C*) was taken from the good silage. One gram of silage was weighed into sterile water and dilutions of 1,000, 10,000, and 100,000 made. The suspensions were plated in duplicate on agar media.

Immense numbers of bacteria were found in the *A* samples of all the cans, the numbers being estimated as 600 million per gram of silage. Fewer bacteria were found in the *B* samples and least in the *C* samples. In the latter samples the calculated numbers per gram for the different cans ranged from 6 millions to 60 millions. Bacteria counts in the samples did not differ according to treatments applied.

Altho the numbers of bacteria in the *A, B,* and *C* samples were different, there were no evidences of differences in the kinds of bacteria present.

No further experiments with disinfectant solutions were carried out, but attention was given to covering the exposed surface of the corn in the silo.

Covering Exposed Surfaces.—Ten small metal cans were filled September 12, 1929. Thirty pounds of cut corn were placed in each can, the corn being thoroly tamped. Coverings of different kinds were applied as shown in Table 11. These were removed on December 10, and samples taken for analysis.

The lime when removed was caked and there was an air space between it and the silage. The silage at the surface was dry. The lime seemed to have but little effect in preserving the corn, as may be seen from Table 11.

The sawdust coverings were more effective in reducing losses than the lime. The use of 15 pounds of covering per square foot caused greater savings than 10 pounds. The use of roofing material, which was applied next to the corn, was distinctly more advantageous than the use of sawdust alone (Table 11).

The three small wooden silos already described were used in 1928, 1929, and 1930 for experiments with silage coverings. The results are shown in Tables 12 and 13.

The use of thermofill was the feature of the 1928 trials. This is

TABLE 11.—EFFECT OF COVERING SURFACE OF CORN ON AMOUNT OF GOOD SILAGE RECOVERED

Silo No.	Amount of corn ensiled	Covering applied	Amount of covering per square foot	Recovery of corn ensiled	
				Good silage	Air-dry matter[a]
	lbs.		*lbs.*	*lbs.*	*perct.*
1	30	Hydrated lime	10	20.3	65
2	30	Hydrated lime	5	19.7	63
3	30	Hydrated lime	2.5	18.6	60
4	30	Hydrated lime	1.25	19.1	62
5	30	None	..	18.2	59
6	30	Sawdust only	15	23.2	75
7	30	Sawdust and roofing	15	26.3	85
8	30	Sawdust only	10	21.0	68
9	30	Sawdust and roofing	10	23.4	75
10	30	None	..	16.9	54

[a]In terms of air-dry matter ensiled.

an inert material, fibrous and powdery in form, used in insulating buildings. A good grade of single-ply roofing paper was applied first. This was fitted roughly to the circle of the silo and the joints well lapped. The silage in silo No. 3 was left uncovered.

The amount of spoilage in the silos with surfaces covered with thermofill was very small, the spoiled area being confined to sections

TABLE 12.—EFFECT OF COVERING EXPOSED SURFACE OF SILAGE ON RECOVERY OF SILAGE FROM SMALL SILOS

Silo No.	Weight of silo before filling	Amount of corn ensiled	Amount of covering added	Weight of silo after emptying	Silage recovered			Proportion of corn ensiled recovered as good silage
					Good	Spoiled	Total	
1928 experiment using thermofill and roofing paper								
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*perct.*
1	1 024	1 511	200	1 050	1 403	59	1 462	92.9
2	949	1 500	100	974	1 357	87	1 444	90.5
3	962	1 608	0	1 010	1 164	281	1 445	72.4
1929 experiment using sawdust, plank cover, and concrete								
1	1 021	1 500	162[a]	1 045	1 372	90	1 462	91.5
2	949	1 500	162[b]	973	1 382	86	1 468	92.1
3	964	1 500	0	1 013	1 023	255	1 278	68.2
1930 experiment using asphalt and paraffin								
1	1 015	1 055	87[c]	1 034	990	9	999	93.8
2	941	1 047	0	977	691	194	885	66.0
3	957	1 046	30[d]	971	855	145	1 000	81.7

[a]Roofing paper 12 pounds; plank cover and broken concrete 150 pounds. [b]Roofing paper 12 pounds; sawdust 150 pounds. [c]Asphalt. [d]Paraffin.

about 8 inches wide and 8 inches deep next the walls. The surface silage in the centers of the treated silos was in perfect condition so far as could be discerned. Recovery of good silage in these silos exceeded 90 percent of the weight of the corn ensiled, while in the untreated silo only 72 percent was recovered (Table 12). A part of the loss in weight was caused by absorption of water by the silo walls. Recovery of dry matter was about 84 percent in the treated silos compared with 69 percent in the untreated silos (Table 13).

TABLE 13.—EFFECT OF COVERING EXPOSED SURFACE OF SILAGE ON RECOVERY OF DRY MATTER

Silo No.	Amount of corn ensiled	Amount of covering per silo	Dry matter in corn as ensiled		Dry matter in good silage as removed		Proportion of dry matter ensiled recovered in good silage
	1928 experiment using thermofill and roofing paper						
	lbs.	*lbs.*	*perct.*	*lbs.*	*perct.*	*lbs.*	*perct.*
1	1 511	200	21.87	330.5	19.93	279.6	84.6
2	1 500	100	21.87	328.1	20.23	274.5	83.7
3	1 608	0	21.87	351.7	20.73	241.3	68.6
	1929 experiment using sawdust, plank cover, and concrete						
1	1 500	162	33.02	495.3	32.59	447.1	90.3
2	1 500	162	33.02	495.3	33.75	466.4	94.2
3	1 500	0	33.02	495.3	31.41	321.3	64.9
	1930 experiment using asphalt and paraffin						
1	1 055	87	30.26	319.2	26.76	264.9	82.9
2	1 047	0	30.26	316.8	26.68	184.4	58.2
3	1 046	30	30.26	316.5	29.51	252.3	79.7

Weekly weighings of the silos showed that Silo 1 reached its minimum weight two weeks after filling, while Silo 2 reached its minimum four weeks after filling (Table 14). Silo 3, which was untreated, continued to lose weight until it was emptied on December 15, three months after filling. The losses which occurred during the period from two weeks after filling until opening were for Silo 1, none; Silo 2, 2 pounds; Silo 3, 49 pounds.

It had been assumed in planning these experiments that the best covering materials would be those which are naturally good insulating materials because they are poor heat conductors and also are in finely divided form. The 1928 experiments, however, led to the belief that this theory was inexact and that the best coverings were those which provided both an air-tight seal and a weight of 10 pounds or more per square foot evenly distributed. The 1929 experiments, therefore, were planned to test out the new theory.

TABLE 14.—CHANGES IN WEIGHTS OF SILAGE AFTER FILLING OF SILOS
(Gross weights of silos and silage expressed in pounds)

Date	Silo 1	Silo 2	Silo 3
1928 experiments			
	(Thermofill cover)	(Thermofill cover)	(No cover)
September 14	2 735	2 549	2 570
September 28	2 719	2 530	2 509
October 12	2 718	2 528	2 486
October 29	2 714	2 527	2 472
November 9	2 717	2 529	2 469
November 23	2 719	2 529	2 464
December 7	2 718	2 528	2 461
December 14	2 719	2 528	2 460
Loss	16	21	110
1929 experiments			
	(Plank cover)	(Sawdust cover)	(No cover)
September 12	2 686	2 614	2 464
September 19	2 676	2 600	2 374
October 3	2 673	2 600	2 350
October 17	2 673	2 598	2 332
October 31	2 674	2 597	2 317
November 14	2 674	2 599	2 310
November 28	2 668	2 595	2 299
December 11	2 674	2 595	2 295
Loss	12	19	169
1930 experiments			
	(Asphalt cover)	(No cover)	(Paraffin cover)
September 18	2 158	1 991	2 053
October 3	2 121	1 936	2 038
October 16	2 119	1 918	2 034
November 1	2 110	1 895	2 032
November 13	2 118	1 886	2 032
November 29	2 117	1 870	2 027
December 12	2 121	1 864	2 030
Loss	37	127	23

A tongued and grooved plank cover was made to fit loosely inside Silo 1. Roofing material was applied next to the corn and the plank cover placed on it. Blocks of broken concrete were set on the plank to give a fairly even distribution of weight. The total weight of the covering was the same as in Silo 2, in which roofing material and sawdust were used. The coverings weighed approximately 15 pounds to the square foot. The silage in Silo 3 was leveled and tramped and given no further treatment.

More than 90 percent of the corn ensiled in Silos 1 and 2 was recovered 90 days after filling, while only 68 percent was recovered from Silo 3 (Table 12). Upon emptying the silos it was found that as in

the previous year the only spoiled silage in Silos 1 and 2 was located in a small section about 8 inches wide and 6 to 8 inches deep next the walls. The silage in the center was of good color and condition, altho that in Silo 1 was better than that in Silo 2. The silage in Silo 3 was spoiled over the entire surface to a depth of 12 to 14 inches. Recoveries of dry matter corresponded closely to recoveries of gross weights of silage, 90 percent or more of the covered silage and but 65 percent of the uncovered being recovered (Table 13). Altho the proportions of good silage recovered from the treated silos in 1928 and 1929 were about the same, the proportions of dry matter recovered from treated silos was distinctly higher in 1929 than in 1928.

Loss of weight of the silos tallied in a general way with the preceding year (Table 14). Silos 1 and 2 lost weight for about 5 weeks, while Silo 3 continued to lose weight for the entire 90-day period. The losses in weight were: Silo 1, 12 pounds; Silo 2, 19 pounds; Silo 3, 169 pounds.

A test of the value of asphalt and paraffin as covering materials was made in the 1930 experiments. Before filling was quite completed, roofing material was applied vertically against the walls to prevent the asphalt and paraffin from adhering to the walls. This was done so that the corn and coverings could settle evenly in the silos. The asphalt was melted in a roofler's melting pot and applied directly to the cut corn. The paraffin was melted in pails placed in hot water and applied directly to the corn by means of a garden sprinkling can. Very little spoilage occurred in the asphalt-treated silo, the recovery of good silage being over 90 percent (Table 12). The recovery from the silo treated with paraffin was about 82 per cent. Altho the paraffin formed a seal over the silage, the weight of the covering was insufficient to prevent some air from entering between the covering and the corn. The covering was evidently of value, however, judging by a recovery of only 66 percent of the silage as good silage, in the untreated silo (Table 12). This is further confirmed by the recoveries of dry matter as shown in Table 13.

Straw was also employed as a covering. In 1929, 1,680 pounds of straw was applied by means of a silo filler to the corn in a 16-by-40-foot tile silo immediately after it had been nearly filled with corn. The straw was soaked with water just before it was blown into the silo. Four days later the straw was tramped and wet down with water.

When the straw was removed several months later, several wagon loads of spoiled silage were also removed. The covering seemed to have had some beneficial effects, however, judging by a comparison of the recoveries of good silage from this silo and from untreated silos. It was believed that the weight of the covering, which was a little less than 10 pounds to the square foot, was insufficient.

Straw was again used as a covering for a 16-by-40-foot tile silo

in 1930. Before applying the straw a good grade of roofing material was laid over the corn, the joints being well lapped. About 2,450 pounds of straw was soaked with water and blown into the silo. The rate of application was about 15 pounds to the square foot of surface. The straw was wet down daily for a week after being applied and about half a bushel of oats was sown on top of the straw.

The only spoilage which occurred was a small amount next the wall and this was confined to an area about 8 to 12 inches inward from the wall and extending downward an equal distance. The silage over the remainder of the surface appeared to be in excellent condition, no spoilage whatever being evident.

The covering experiments have shown, therefore, that the spoilage of silage which normally occurs at the surface can be reduced to very small proportions. There appear to be two essential features in a suitable cover. One is the use of some material, such as roofing, which will, when properly weighted, form an air-tight cover over the surface of the silage. The second is the application of sufficient weight to pack the silage near the surface and thus prevent air from entering. The weight must be at least 10 pounds to the square foot and preferably as much as 15 pounds. The kind of material used in the covering may vary widely in character as long as it fulfils the requirements outlined and does not taint the silage or injure its feeding value in other ways.

FEEDING VALUE OF SILAGE FROM DIFFERENT VARIETIES

The acre-yield of varieties of corn grown for silage is one of the important criteria in arriving at the value of the different varieties. The livestock feeder is also interested in the yield of digestible matter, which is fully as important as the tonnage; in palatability, for substances which an animal refuses to eat are of no value to it as feed; and in the particular effects a variety of silage may have upon the animals consuming it. Even tho a feed is readily consumed, it may have some undesirable effects, producing, for example, a too laxative condition. These are problems which cannot be answered satisfactorily by chemical analysis alone but require feeding tests as well.

Digestibility and Energy Value

Digestion coefficients for silage of the three varieties used in feeding trials, namely, Reid, Virginia, and Cocke, were ascertained in experiments with sheep. These varieties were considered representative of the types of corn under investigation, that is, the grain type, the late-maturing single ear, and late-maturing prolific type, respectively.

The digestion trial was carried on with the cooperation of the di-

vision of Animal Nutrition of this Station, all of the analyses being made by that division. The feeding periods extended from January to March, 1925, the silage fed being from corn grown in 1924.

Six sheep weighing 85 to 100 pounds each were used in the experiment, all of these being fed silage for a given period from each of the three varieties of corn in succession. During a preliminary period of 10 days at the dairy barns, the particular kind of silage to be fed in the digestion trial was fed to the sheep individually in amounts which it was found they would consume with little waste. Silage was the only feed given during the preliminary periods and the periods of digestion trials, except for an allowance of a mineral mixture fed on the silage at the rate of 15 grams per head daily.

The refused portion consisted chiefly of cobs. After each feeding the cobs were collected from the mangers, ground in a food chopper and mixed with the silage given at the next feeding. In this way almost complete consumption of the cobs was secured. It was observed during these preliminary feeding periods, as well as during the feeding trials with dairy cows, that the cobs of Reid silage were refused to a greater extent than those from the other silages, presumably because these cobs were more mature and hence harder.

Live weights were recorded at the beginning and close of each preliminary period. The amount of silage consumed was insufficient to prevent losses of weight, the extent of the losses for the series of experiments ranging from about 4 to 12 pounds per head.

At the end of each preliminary period the sheep were taken to the Animal Nutrition laboratory and placed in individual metabolism crates. Each digestion trial covered a period of 10 days.

Some difficulty was experienced in obtaining complete silage consumption by the sheep, particularly with the Cocke variety. The Reid silage was consumed readily, except for the cobs, but the Cocke silage was distinctly unpalatable to two of the sheep, with the result that their consumption was lowered from the level of 4 pounds of silage per head daily to 3 and 2.5 pounds respectively.

The three kinds of silage differed distinctly in dry matter content (Table 15), the Reid silage having about 27 percent dry matter, the Virginia 22 percent, and the Cocke 19 percent. The dry-matter content of the Reid silage was a little less than what it should be from corn ensiled at the ideal stage for ensiling (page 85); the dry-matter contents of the Virginia and Cocke silage were those of immature corn. Nitrogen-free extract comprized a greater proportion of the dry matter of the Reid silage than of the Virginia, and the Virginia excelled the Cocke in this respect. The proportions of crude fiber in the dry matter of the three varieties, however, were the reverse of the nitrogen-free extract; that is, the Cocke silage was highest in crude fiber, followed by Virginia, with Reid lowest.

TABLE 15.—COMPOSITION OF SILAGE FED DURING DIGESTION TRIALS WITH SHEEP

Silage from—	Sample	Dry matter	Crude protein	N-free extract	Crude fiber	Ether extract	Ash	Gross energy per gram
		Fresh-matter basis						
		perct.	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*sm. cal.*
Reid Yellow Dent...	B	26.53	2.26	15.21	6.64	.78	1.64	1 186
	R	27.84	2.20	16.29	7.05	.74	1.56	1 233
Virginia Horsetooth..	B	20.22	1.76	10.52	6.12	.41	1.41	927
	R	23.68	2.10	12.93	6.37	.64	1.64	1 058
Cocke Prolific.....	B	18.51	1.68	8.50	6.33	.59	1.41	832
	R	19.48	1.67	9.20	6.74	.51	1.36	893
		Dry-matter basis (average values)						
Reid Yellow Dent.....		100	8.20	57.94	25.18	2.80	5.89	4 449
Virginia Horsetooth.....		100	8.79	53.42	28.45	2.39	6.95	4 522
Cocke Prolific.....		100	8.82	46.59	34.40	2.90	7.29	4 521

The digestion coefficients obtained in the trials with the three kinds of silage (Table 16), show that in digestibility of its dry matter Reid silage was highest, Virginia next, and Cocke lowest. Undoubtedly this result is to be accounted for chiefly by the superior digestibility of the nitrogen-free extract of one variety over another, for this constituent is the largest single ingredient of the silage and the differences in digestibility were greater for it than for any of the other individual nutrients. The digestion coefficients for crude fiber show an opposite trend, the coefficient for the Cocke silage being highest, the Virginia lower, and the Reid lowest. This is a natural result since the more mature the plant the lower the digestibility of the fiber.

The digestible nutrients in 100 pounds of the different kinds of silage (Table 17) were calculated by applying the coefficients of digestibility (Table 16) to the figures showing composition (Table 15). Reid silage furnished about 18 pounds of total digestible nutrients in

TABLE 16.—DIGESTION COEFFICIENTS OF SILAGE FROM VARIETIES OF CORN USED IN DIGESTION TRIALS WITH SHEEP AND FEEDING TRIALS WITH MILK COWS

Silage from—	Dry matter in silage as fed	Coefficients of digestibility					
		Dry matter	Crude protein	N-free extract	Crude fiber	Ether extract	Gross energy
	perct.						
Reid Yellow Dent.....	27	63	51	75	54	82	64
Virginia Horsetooth.....	22	60	54	70	58	75	64
Cocke Prolific.....	19	55	51	62	61	78	61

TABLE 17.—DIGESTIBLE NUTRIENTS IN SILAGE FED DURING DIGESTION TRIAL

Silage from—	Digestible nutrients in 100 pounds of silage						
	Dry matter	Crude protein	N-free extract	Ether extract	Crude fiber	Gross energy	Total digestible nutrients[a]
	lbs.	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*cal.*	*lbs.*
Reid Yellow Dent	17.2	1.13	11.82	.62	3.68	780	18.03
Virginia Horsetooth	13.18	1.05	8.29	.40	3.64	624	13.88
Cocke Prolific	10.46	.86	5.47	.43	3.96	523	11.25

[a]The sum of the digestible ether extract multiplied by 2.25, plus the digestible crude protein, digestible nitrogen-free extract, digestible ether extract, and digestible crude fiber.

100 pounds of silage, the Virginia silage about 14, and the Cocke about 11. The Reid silage, therefore, was about 60 percent higher in digestible-nutrient content than the Cocke silage. The Reid silage had a slightly higher content of total digestible nutrients and digestible gross energy for each 100 pounds of total dry matter than the Virginia silage and the Cocke silage was slightly lower in these respects than the Virginia silage. These relationships may be accounted for by the increased proportions of dry matter in the grain as the corn plant approaches maturity, with the resultant increase in nitrogen-free extract.

TABLE 18.—METABOLIZABLE ENERGY OF SILAGE FROM VARIETIES OF CORN USED IN DIGESTION AND FEEDING TRIALS

Silage from—	Dry matter in silage fed	Metabolizable energy of silage consumed	
		Per 100 pounds digestible organic matter	Per 100 pounds of silage
	perct.	*therms*	*therms*
Reid Yellow Dent	27.19	168	29.00
Virginia Horsetooth	21.95	178	23.65
Cocke Prolific	19.00	180	19.24

The data obtained during the digestion trials made it possible to calculate the metabolizable energy of the silage consumed (Table 18). The Virginia and the Cocke silages were higher than the Reid in metabolizable energy per 100 pounds of digestible organic matter, but the metabolizable energy of the silages as fed was about proportional to their dry matter contents, that is, Reid was highest, Virginia next, and Cocke lowest.

Results Obtained in Feeding Trials With Dairy Cows

Value for Milk Production.—Feeding trials in which dairy cows were employed as experimental animals were carried out in 1923-24

and in 1924-25. Essentially the same plan of procedure was followed in both years.

Three wooden stave silos, each 10 by 24 feet in size, were filled in September with the varieties of corn chosen for the feeding tests, namely, Reid, Virginia, and Cocke. Feeding trials were begun in November, 1923, and in October, 1924. The experimental periods were four weeks in length and each was preceded by a preliminary period of one week during which the kind of silage being fed was gradually replaced by the kind of silage to be fed during the following experimental period. In both trials seven cows were used as a single group. A larger number of cows was started on the experiment each year but seven were finally selected as being well suited for the purpose. Some data regarding the cows are given in Table 19.

TABLE 19.—DAIRY COWS USED IN FEEDING TRIALS

Animal No.	Breed	Age			Days since last calving to beginning of trial
		Years	Months	Days	
1923-24					
257	Holstein	6	2	4	33
259	Holstein	5	9	17	214
263	Holstein	5	11	12	391
279	Jersey	8	0	23	55
320	Ayrshire	3	1	6	66
321	Ayrshire	2	7	1	47
135	Ayrshire	15	0	7	66
1924-25					
254	Holstein	9	9	9	143
259	Holstein	6	8	11	86
301	Guernsey	4	2	3	31
308	Holstein	4	5	0	20
309	Holstein	3	10	13	54
316	Holstein	3	10	4	28
321	Ayrshire	3	5	25	30

An effort was made to have the cows consume as much of the silage as possible. The amounts eaten during the first two or three weeks of the experiment increased considerably over the amounts to which the cows had been accustomed under herd routine. About 40 pounds of silage was consumed daily per cow in the first trial and 45 pounds in the second trial, altho the amounts ranged from 30 pounds daily for some of the smallest cows to over 65 pounds daily for the largest.

The hay fed was a good grade of alfalfa, and an attempt was made to keep the amounts consumed constant from week to week. The grain mixtures fed contained 14 to 15 percent total protein and were fed in proportion to milk production. The amounts to be fed daily during the next seven days were adjusted at the close of each week. The amounts of feed consumed and gains in weight are shown in Table 20.

The milk yielded by each cow at each milking was weighed and

TABLE 20.—SUMMARY OF FEED CONSUMED DURING FEEDING TRIALS WITH DAIRY COWS

(Results expressed in averages per cow)

Period	Kind of silage	No. of cows	Feed consumed			Silage orts	Live weights	Gain in weight
			Silage	Hay	Grain			
1923-24			*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
I	Reid	7	991	140	274	11	1 060	7
II	Virginia	7	1 211	140	276	13	1 072	16
III	Reid	7	1 221	136	246	26	1 090	9
IV	Cocke	7	1 217	141	227	57	1 103	12
V	Reid	7	1 208	137	216	36	1 110	3
1924-25								
I	Reid	7	1 108	193	339	11	1 083	29
II	Cocke	7	1 377	194	340	0	1 121	23
III	Reid	7	1 355	190	309	10	1 142	14
IV	Virginia	7	1 460	188	271	12	1 165	16
V	Reid	7	1 245	196	246	14	1 178	13

sampled for butterfat determinations by the Babcock method. Composite samples were tested weekly.

Samples of the silage, hay, and grain were taken regularly thruout each experimental period for analysis. Coefficients of digestibility obtained in the digestion trials already described were used in calculating the digestible nutrient content of the three kinds of silage. Average coefficients of digestibility were applied to the analyses of the alfalfa hay and grain mixtures. The calculated amounts of digestible nutrients consumed, together with the amounts of milk yielded, are shown in Table 21.

TABLE 21.—SUMMARY OF DIGESTIBLE NUTRIENTS CONSUMED AND MILK YIELDED IN FEEDING TRIALS

(Results expressed in averages per cow)

Period	Kind of silage	Milk yield (F.C.M.)[a]	Relative production of milk	Total digestible nutrients consumed in—				Relative amounts of total digestible nutrients consumed
				Silage	Hay	Grain	All feed	
1923-24		*lbs.*	*perct.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*perct.*
I	Reid	743	100.0	229.0	74.6	192.8	496.4	100.0
II	Virginia	707	95.2	225.9	74.6	199.3	499.8	100.7
III	Reid	649	87.4	282.4	72.2	181.4	536.0	108.0
IV	Cocke	563	75.9	219.1	75.0	164.3	458.4	92.3
V	Reid	532	71.6	277.5	72.7	156.2	506.4	102.0
1924-25								
I	Reid	951	100.0	210.0	94.4	242.4	546.9	100.0
II	Cocke	851	89.5	182.5	94.7	243.1	520.2	95.1
III	Reid	824	86.6	269.2	92.6	225.0	586.8	107.3
IV	Virginia	750	78.8	228.7	91.7	192.4	512.8	93.8
V	Reid	683	71.8	225.4	95.5	182.3	503.2	92.0

[a]Milk yield corrected to an energy equivalent basis of 4-percent milk by application of formula F.C.M. = 0.4 × milk in pounds + 15 × fat in pounds.

The milk and butterfat yields have been corrected to an energy-equivalent basis of 4-percent milk according to the method of Gaines and Davidson.[a] The relative production of milk for each period was calculated, using the amount produced in Period I as 100 percent (Table 21). It may be noted that the decline in milk yield was greater when changing from Reid silage to Cocke silage than when changing

TABLE 22.—EFFICIENCY OF PRODUCTION OF MILK DURING FEEDING TRIALS
(Results expressed in average per cow)

Period	Kind of silage	Digestible protein used for		Total digestible nutrients used for—			Nutrients used per 100 pounds F.C.M.	
		Maintenance	Milk	Maintenance	Gain	Milk	Digestible protein[a]	Total digestible nutrients
1923-24		*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
I	Reid	20.8	41.1	235.4	17.5	243.5	5.53	32.8
II	Virginia	21.0	44.7	238.0	40.0	221.8	6.33	31.4
III	Reid	21.4	42.1	242.0	22.5	271.5	6.49	41.8
IV	Cocke	21.6	41.9	244.9	30.0	183.5	7.44	32.6
V	Reid	21.8	42.3	246.5	7.5	252.4	7.95	47.4
All periods		....	....	.....	....	.....	....	36.7
1924-25								
I	Reid	21.2	52.3	240.5	72.5	233.9	5.50	24.6
II	Cocke	22.0	56.7	248.9	57.5	213.8	6.66	25.1
III	Reid	22.4	53.1	253.6	35.0	298.2	6.44	36.2
IV	Virginia	22.8	49.0	258.7	40.0	214.1	6.53	28.5
V	Reid	23.1	45.1	261.6	32.5	209.1	6.60	30.6
All periods		....	....	.....	....	.....	....	28.8
Average of both trials		....	....	.....	....	.....	....	32.3

[a]In this calculation no allowance was made for the protein used for gain in weight.

from Reid to Virginia silage. The greater decline is assumed to have been caused by the low intake of digestible nutrients during the periods when Cocke silage was fed, and this in turn is accounted for by the low dry-matter and digestible-nutrient content of the Cocke silage.

The efficiency in the use made of the digestible nutrients during the feeding trials was calculated. The results of the calculations are shown in Table 22. In making these calculations it was necessary to make several assumptions. For instance, it was assumed that a pound of gain in weight required exactly the same number of pounds of digestible nutrients in the case of all cows. This may not have been the case for the gain of one cow may have consisted more largely of fat than the gain of another cow, which of course would involve a greater consumption of nutrients per pound of gain. Were all the assumptions

[a]Gaines, W. L. and Davidson, F. A. Relation Between Percentage Fat Content and Yield of Milk. Ill. Agr. Exp. Sta. Bul. 245. 1923.

and calculations made correctly, then the amounts of digestible nutrients used per 100 pounds of fat-corrected milk (last column of Table 22) should have been the same in all periods. As it is, the amounts for Periods III and V of the 1923-24 trial and for Period III of the 1924-25 trial, when Reid silage containing large amounts of nutrients was fed, are very high. Omitting these, the figures for the other periods of each trial are in substantial agreement. This indicates that the digestible-nutrient content of the different silages as determined in the digestion trials proved to be a good index of their values.

It is recognized that in feeding trials like these many variables, such as decline in lactation and changes in live weight from period to period, changes in weather conditions and in the dry-matter content of the silage, make it impossible to arrive at an exact or even a close evaluation of a feed which contributes only 40 to 50 percent of the total digestible-nutrient intake. The feeding trials did, however, yield important data on the relative values of the different silages, which can be summarized as follows:

1. Silages from the Reid, Virginia, and Cocke varieties of corn grown and ensiled under the conditions described proved palatable to dairy cows when fed as part of a well-balanced ration containing good quality legume hay.

2. Silages of the kinds fed, in the amounts and combinations described, produced no observable harmful or undesirable effects upon the cows.

3. Cocke and Virginia silages, as ensiled at this Station, were of lower value for milk production than the Reid silage.

Calculations of the amounts of digestible nutrients used for milk production during the feeding trials indicate that the values determined in the digestion trials are in substantial agreement with the results of the feeding trial. This statement is made with reservations in view of the many variables encountered in a feeding trial.

Value for Gain in Weight.—A feeding trial having for its object a comparison of the value of silages made from different varieties of corn for putting weight on cattle was conducted during the months January to May, 1928, using dry milk cows and yearling dairy heifers as experimental animals. Fourteen animals were divided into two groups on the basis of age, weight, stage of gestation, and general condition. Each animal of Group A was paired with an animal in Group B. The two animals of each pair were fed different silages in each experimental period and at the end of the period the gains in weight were tabulated.

In the trial there were four experimental periods, each 4 weeks in length except the last, which was terminated at the end of 2 weeks by several reactions to the tuberculin test. A 2-weeks' preliminary

period preceded the first experimental period. A 1-week transition period elapsed between the experimental periods.

It was necessary to drop six of the cows from the experiment at the end of the second experimental period on account of advancing gestation.

The feeding was regulated in such a manner that the amounts consumed by the two animals of a pair were exactly the same. An effort was made to have the animals consume as much silage as possible, the amount fed any one animal, of course, being limited by the appetite of its pair mate. The amounts of silage consumed ranged from 30 pounds per head daily for the heifers to as much as 58 pounds per head daily for the larger cows. Similarly the amounts of hay consumed ranged from 4 to 9 pounds per head daily. From the standpoint of experimental results a grain mixture could have been substituted to advantage for the clover hay, but it was necessary to consider the health of the animals and feed them some good-quality hay in order to supply minerals and vitamins.

The summary of the feed records presented in Table 23 show that the amounts of feeds consumed by the two groups of animals were the same during each period, with the exception of very slight differences in Period I. The gains of the groups receiving the Reid silage were greater in all periods than those receiving silage from the Cocke and Virginia varieties. This is an expected result, since it is shown in Table 24 that the Reid silage was highest in its dry-matter content and that the intake of dry matter by the group fed the Reid silage was therefore greater than by the group receiving the same amount of another kind of silage during the same period.

The results obtained under the plan followed demonstrate the lower values of the Cocke and Virginia silages in comparison with the Reid silage when fed in the same quantities of gross feed. One of the fundamental principles of economical milk production is that the greater the amount of milk yielded by an individual cow, the lower the feed cost per unit of production. In order to give high milk yields it is necessary that cows consume large amounts of digestible nutrients and, if silage very high in water content is fed, the intake of digestible nutrients is less than when silage made from well-matured corn is given. The feeding trial under discussion therefore demonstrated that the gains in weight were distinctly smaller when Cocke and Virginia silages were fed nearly to the limit of appetite than when the same amounts of Reid silage were fed (Table 23). The differences in gains are to be attributed chiefly to the differences in intake of dry matter, altho the higher nutritive value per pound of dry matter of the Reid silage would also account for a part of the difference. Such a difference in the nutritive properties of the dry matter of the different silages was not clearly demonstrated in this feeding trial, however.

TABLE 23.—COMPARATIVE FEEDING VALUE OF SILAGES MADE FROM DIFFERENT VARIETIES OF CORN, AS ASCERTAINED IN TESTS WITH DRY MILK COWS AND DAIRY HEIFERS

Animal No.	Feed consumed		Gain in weight	Animal No.	Feed consumed		Gain in weight
	Silage	Clover hay			Silage	Clover hay	
	Period I—Reid Yellow Dent				Period I—Cocke Prolific		
	lbs.	*lbs.*	*lbs.*		*lbs.*	*lbs.*	*lbs.*
6[a]	1 067	253	30	806[a]	1 067	253	34
12	1 459	253	51	24	1 459	253	35
15	1 219	238	14	67	1 219	235	12
732	1 135	202	31	10169	1 135	202	5
3402	712	117	27	3404	712	114	8
3403	662	140	27	3407	665	140	6
3645	356[b]	56[b]	15[b]	36454	356[b]	56[b]	19[b]
Totals	6 610	1 259	195		6 613	1 253	119
	Period II—Reid Yellow Dent				Period II—Cocke Prolific		
806	1 177	252	27	6	1 177	252	35
24	1 552	252	23	12	1 552	252	27
67	1 255	235	23	15	1 255	235	—4
10169	1 150	196	24	732	1 150	196	14
3404	817	112	24	3402	817	112	18
3407	873	136	41	3403	873	136	7
36454	817	112	26	3645	817	112	19
Totals	7 641	1 295	188		7 641	1 295	116
Totals, 14 animals, Periods I and II	14 251	2 554	383		14 254	2 548	235
	Period III—Virginia Horsetooth				Period III—Reid Yellow Dent		
732	1 155	196	4	10169	1 155	196	11
3402	868	112	23	3404	868	112	35
3403	896	140	17	3407	896	140	40
3645	877	112	30	36454	877	112	30
Totals	3 796	560	74		3 796	560	116
	Period IV[b]—Virginia Horsetooth				Period IV[b]—Reid Yellow Dent		
10169	588	98	1	732	588	98	6
3404	448	56	15	3402	448	56	23
3407	441	70	9	3403	441	70	20
36454	443	56	13	3645	443	56	21
Totals	1 920	280	38		1 920	280	70
Totals, 8 animals, Periods III and IV	5 716	840	112		5 716	840	186

[a]Animals with numbers shown on the same line were pair mates. Thus Nos. 6 and 806 were pair mates, etc. [b]Fourteen-day period.

TABLE 24.—RELATION OF AMOUNTS OF DRY MATTER CONSUMED TO GAINS IN WEIGHT BY DRY MILK COWS AND DAIRY HEIFERS IN FEEDING TRIALS WITH SILAGES FROM DIFFERENT VARIETIES OF CORN, 1928

Period	Group of animals	Kind of silage	Dry matter in—		Dry matter consumed in—		Gains in weight	Dry matter consumed per pound gain in weight
			Silage	Clover hay	Silage	Clover hay		
			perct.	*perct.*	*lbs.*	*lbs.*	*lbs.*	*lbs.*
I	A	Reid	34.40	84.78	2 274	1 067	195	17.1
II	B	Reid	34.44	84.78	2 632	1 098	188	19.8
Totals both groups		.....	.....	.....	4 906	2 165	383	18.5[a]
I	B	Cocke	25.41	84.78	1 680	1 062	119	23.0
II	A	Cocke	25.02	84.78	1 912	1 098	116	25.9
Totals both groups		.....	.....	.....	3 592	2 160	235	24.5[a]
III	B	Reid	34.20	85.63	1 298	480	116	15.3
IV	A	Reid	35.45	85.63	681	240	70	13.2
Totals both groups		.....	.....	.....	1 979	720	186	14.5[a]
III	A	Virginia	26.42	85.63	1 003	480	74	20.0
IV	B	Virginia	28.70	85.63	551	240	38	20.3
Totals both groups		.....	.....	.....	1 554	720	112	20.1[a]

[a]Average.

It may be concluded that, in feeding practice, silage from well-matured corn is preferable for high-producing cows, but for cows of moderate production, dry cows, and young stock, silage made from less-mature corn will furnish satisfactory amounts of nutrients.

The method of Student[a] was applied in studying the significance of the gains in weight during each of the periods of the experiment. The odds that the greater gains of the animals receiving Reid silage were significant, that is, not due to chance alone, are as follows: Period I, 31 to 1; Period II, 15 to 1; Period III, 16 to 1; Period IV, 150 to 1.

Acidity of Corn Silage.—A number of determinations were made of the amounts of acid in the varieties of silage used in the feeding trials. It was assumed that there might be a direct relation between acid content and palatability, altho little evidence could be observed of a lack of palatability to the dairy cows of any of the silages fed to them. When silage was fed as part of a well-balanced ration containing liberal amounts of good-quality legume hay, it was freely consumed and no distinct differences between the silages made from the three varieties of corn were observed. Offered as the only feed to sheep during digestion trials, however, the Cocke silage (page 94) which had the highest average acid content, proved unpalatable to some animals, as already noted.

The acid contents of the different kinds of silage (Table 25) were

[a]Biometrika, 6, 19, 1908.

TABLE 25.—ACIDITY IN CORN SILAGE
(Total acidity calculated in terms of acetic acid)

Variety of corn	Crop year	Date of sampling	Dry matter in silage	Acid in fresh silage	Acid in terms of dry matter in silage
			perct.	*perct.*	*perct.*
Reid	1923	3– 1–24	34.8	1.53	4.40
	1924	10– –24	28.9	2.25	7.79
	1924	1– 6–25	30.1	2.08	6.91
	1926	3–10–27	33.8[a]	2.23	6.60
	1926	3–23–27	33.8[a]	2.21	6.54
	1926	4–25–27	33.8[a]	2.18	6.45
	1927	2–17–28	34.4	1.57	4.56
	1927	3– 1–28	34.2	1.51	4.42
	1927	3–28–28	35.5	1.78	5.01
Virginia	1923	3– 1–24	29.4	2.05	6.97
	1926	3–10–27	24.2[a]	2.17	8.97
	1926	3–23–27	24.2[a]	2.39	9.88
	1926	4–25–27	24.2[a]	1.96	8.10
	1927	3–28–28	26.4	2.35	8.90
Cocke	1923	3–13–24	24.6	1.19	4.84
	1924	11–24–24	22.9	1.87	8.17
	1924	3–30–25	25.4	2.38	9.37
	1924	4–23–25	19.0	1.99	10.47
	1927	2–17–28	25.4	2.31	9.09
	1927	3– 1–28	25.0	1.93	7.72
	1927	3– 7–28	25.0	2.03	8.12

[a]Estimated from analysis of corn as ensiled.

found to vary considerably and to show no consistent differences when calculated in terms of the silage as fed. Considered upon the basis of the percentage of acid in the dry matter of the silage, however, it may be noted that the acid content of the Reid silage was, in general, the lowest of all. Both the Virginia and Cocke silages showed higher acidity than the Reid.

There seems to be quite a marked relationship between dry-matter content and percentage of acidity, altho this is not constant. Thus Table 25 shows that the Reid silage in all but one case was higher in dry-matter content than any other sample of silage analyzed for acidity. There are also some indications within each of the three varieties—Reid, Virginia, and Cocke—that the lower the dry-matter content of the silage the greater the proportion of acid in the dry matter.

It was observed upon feeding the silage made from corn in very immature stages, when the kernels were in the milk stage, that the only portion of the kernel visible in the silage was the hull even tho the hull had not been broken. It is assumed that the kernel contents at this stage of development are readily fermentable and are in part, at least, responsible for the higher acid content of the silage made from immature corn than of the silage made from mature corn.

From this study of the acid contents of silages, it may be concluded that there is a relationship between the stage of development at which corn is ensiled, as shown by its dry-matter content, and the acidity con-

tent of the resulting silage, altho this relationship is not a fixed one; and further that a high acid content tends to lower the palatability of the silage for some animals.

FEEDING VALUE OF SILAGE FROM CORN CANNERY REFUSE

No reports of investigations dealing with the feeding value of silage made from corn cannery refuse were found in the literature on silage. Considerable quantities of husks, overripe and damaged ears, together with cobs, are left as waste at corn canning plants. This waste is sometimes usefully employed as silage or returned to the land as fertilizer.

A wooden silo 10 by 24 feet in size was filled for several seasons with corn cannery refuse obtained from the canning plant of the Department of Horticulture of this Station. The refuse consisted of approximately 30 percent husks, 40 percent cobs, and 30 percent ears. Some of the water used in washing the corn adhered to the refuse, thus increasing its water content. The silage kept well but had a very acid taste. It was fed successfully to young stock during the summer as a supplement to pasture and dry-lot feeding.

A digestion trial in which this kind of silage was fed was carried out in April, 1928, in the laboratory of the division of Animal Nutrition of this Station. The analytical work was conducted thru the courtesy of that division.

Three steers were placed in metabolism stalls and fed silage as the only feed, but they were given access to block salt. The silage proved distinctly unpalatable to one and caused diarrhea in another. One steer, however, ate the silage without waste and was employed for a 13-day digestion trial.

Several hundred pounds of the silage to be used in the digestion trial was placed on a clean concrete floor and mixed thoroly. The silage was then weighed into thin cotton sacks, 8 kilograms of silage being placed in each sack. The silage was mixed and samples were taken at random thruout the weighing process. The sacks of silage were tied and then stored in a refrigerator at a temperature of 28 to 35° F. The silage kept well for the period of the experiment. Two sackfuls of the silage were fed daily.

The composition and digestibility of the silage are shown in Table 26. The dry-matter content of the silage was about 22.5 percent, which is considerably below the optimum. The digestibility of the silage proved to be much higher than one would expect considering the character of the material. The coefficients of digestibility and digestible-nutrient content compare favorably with those of Reid silage, (Tables 16 and 17). The cannery refuse silage, however, was lower in digestible nitrogen-free extract and gross energy. Its metabolizable-energy

TABLE 26.—COMPOSITION AND DIGESTIBILITY OF SILAGE FROM SWEET CORN CANNERY REFUSE
(Steer used in digestion trials)

	Dry matter	Crude protein	N-free extract	Crude fiber	Ether extract	Ash	Gross energy per gram
	perct.	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*sm. cal.*
Composition of refuse as ensiled Sept. 8, 1927.....	22.78	1.94	13.32	5.42	1.04	1.06	....
Composition of silage fed April, 1928.....	22.46	2.19	12.10	5.13	1.71	1.33	1 015
Digestibility of silage.....	68.0	56.5	71.0	70.0	87.0	....	(68.0[a])
Digestible nutrients in 100 pounds of silage.....	15.27	1.24	8.59	3.59	1.49	....	690

NOTE.—The metabolizable energy in 100 pounds of silage is 26 therms; in 100 pounds of digestible organic matter, 176 therms.
[a]Percent.

content corresponded to that of normal silage containing corresponding amounts of dry matter.

The percentage of acidity for silage made from the 1926 corn cannery refuse was about the same as the average percentage for the Virginia and Cocke silages; but the acidity of the 1927 refuse silage, which was that fed in the digestion trial, was considerably higher (Tables 25 and 27). It is believed that this unusually high acid content was responsible for the refusal of silage by one animal during the digestion trial.

TABLE 27.—ACIDITY IN SILAGE FROM CORN CANNERY REFUSE

Crop year	Date of sampling	Dry matter in silage	Acid in fresh silage	Acid in terms of dry matter in silage
		perct.	*perct.*	*perct.*
1926.....	.....	14.5	1.15	7.93
1927.....	3–28–28	22.8	2.81	12.32

SUMMARY AND CONCLUSIONS

An investigation of the value, for silage purposes, of different types and varieties of corn was conducted over a period of six successive years. Late-maturing single-ear varieties (Ardelt, Mexican June, and Virginia Horsetooth) and late-maturing prolific varieties (Cocke Prolific and Garrick Prolific) were compared with varieties maturing grain (including Reid Yellow Dent, Leaming, Boone County White, and Democrat, single-ear varieties, and Illinois Two-Ear, a prolific variety).

All things considered, the grain varieties tested were found superior to the late-maturing varieties for silage purposes. It must be kept in mind, however, that varieties other than those included in this study might give different results, and that even these same varieties might behave differently if grown under soil and climatic conditions dissimilar to those obtaining in this experiment.

The late-maturing varieties yielded a greater weight of silage corn to the acre than the grain varieties, but the grain varieties gave a greater yield of dry matter per acre. Harvesting the late-maturing varieties thus necessitated more labor for each unit of dry matter obtained than harvesting the grain varieties. Slightly greater variations in yield from year to year were noted in the late-maturing varieties.

Sampling the standing crop in the field at weekly intervals showed that a very rapid increase in yield of nutrients occurred during August and September and that harvesting in August or early in September would sacrifice a large part of the feeding value of the crop. The crop reached its maximum fresh (green) weight before the development of the maximum amount of dry matter.

The ears of two of the late-maturing varieties (Virginia Horsetooth and Cocke Prolific) contained about 35 percent of the air-dry matter of the crop, whereas the ears of the four grain varieties (Reid, Leaming, Boone County White, and Illinois Two-Ear) formed 47 percent of the air-dry matter; which indicates that the feeding value per pound of dry matter was greater for the grain varieties. In harmony with this indication was the fact that the grain varieties at the time they were ensiled contained a smaller proportion of fiber than the late-maturing varieties.

Observation of the qualities of silage produced from corn ensiled under a wide range of moisture conditions indicates that when both keeping qualities and palatability of the silage are considered, the most satisfactory stage of development at which to ensile corn is when it has reached a dry-matter content of about 30 percent. A rapid method of determining dry matter in corn in order to ascertain the proper time for ensiling is described (see page 86).

A number of different methods of reducing the losses from spoilage at the surface when silage is not being removed regularly for feeding were tried. Some methods proved unsatisfactory, but an effective method was found, which was covering the silage with a good quality of roofing material at once when the filling is completed and applying to the covering some substance that gives an even distribution of weight amounting to 10 to 15 pounds to the square foot.

Digestion trials with silages from Reid Yellow Dent corn (a grain variety), Virginia Horsetooth (a single-ear late-maturing variety), and Cocke Prolific (a prolific, late-maturing variety) showed that in digestibility the Reid silage was highest, Virginia next, and Cocke lowest.

Since the three kinds of silage ranked in the same order in percentages of dry matter, the Reid silage is seen to have been much higher in percentage of total digestible nutrients than either the Virginia or Cocke silage, and the Virginia silage was higher than the Cocke. The metabolizable energy of the different silages was nearly proportional to the dry-matter content of the silage as fed.

When silage of the three kinds was supplied to sheep as the only feed during digestion trials, the Cocke silage was unpalatable.

Feeding trials for milk production in which silage from the three varieties of corn mentioned above was fed showed that all these silages were palatable when fed as part of a well-balanced ration, and that they had no harmful effects upon the cows. Fed in connection with clover hay to dry cows and heifers, the Reid silage proved highest in value followed by Virginia and Cocke. It is possible that with high-producing cows the use of silage very high in water content may at times limit the intake of nutrients to such an extent that maximum milk production cannot be attained.

Studies of the amounts of acidity in fresh silage showed that the acid in silage made from immature corn may be very high. There seemed to be a direct relationship between the water content of the corn at the time it was ensiled and the percentage of acidity in the silage, altho this relationship was not a fixed one.

The digestibility of silage made from corn cannery refuse was determined and was found to compare favorably with that of Reid silage. On account of its low dry-matter content, however, the feeding value of this silage was below that of Reid silage. It also contained a large amount of acid. When given as the only feed, it proved unpalatable in some cases.

ACKNOWLEDGMENT

The author expresses his thanks for the cooperation of the divisions of Dairy Chemistry and Animal Nutrition in conducting the analytical work involved in this investigation. Most of the analyses of feeds other than those concerned with digestion trials were made by Mr. A. K. Joshi under the direction of Dr. O. R. Overman. The digestion trials were conducted and the necessary analyses made in the laboratories of the division of Animal Nutrition.

The method for rapid drying of samples of green corn and similar materials was developed by Mr. G. T. Boon,[a] a graduate student in Dairy Husbandry, with the assistance of the author.

The device for picking up lodged stalks illustrated in Figs. 2 and 7 was designed by Messrs. J. R. Palfrey and S. H. Williams, employees of the Department of Dairy Husbandry.

[a]Boon, G. T. A modified method of determining dry matter in corn silage. Master's thesis, University of Illinois Library. 1925.

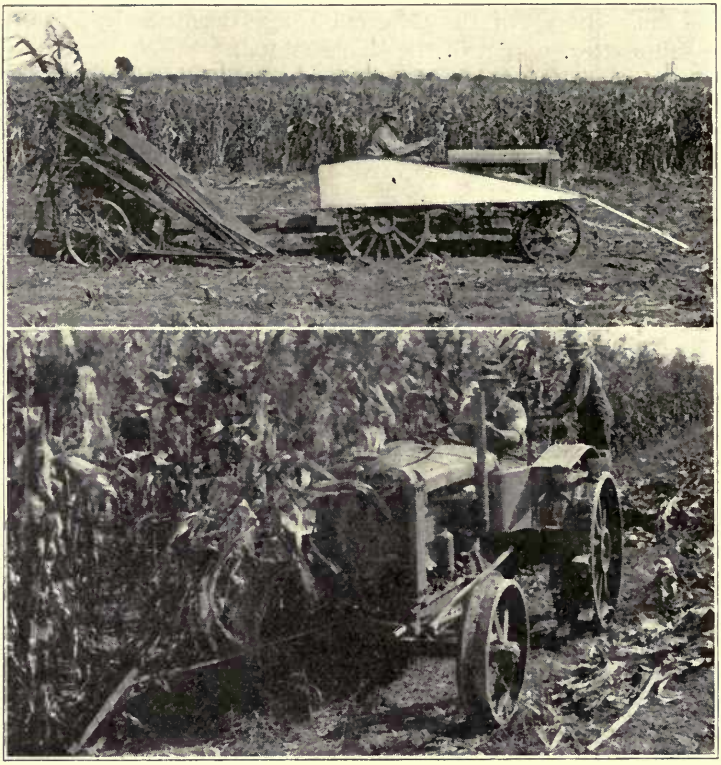

FIG. 7.—IMPROVED DEVICE FOR PICKING UP LODGED CORNSTALKS

This device has several improvements over the one shown in Fig. 2. The projecting arm is jointed about 2 feet from the tip to provide for more flexibility on uneven ground, and the galvanized iron shield aids in keeping stalks out of the tractor wheels.

REVIEW OF THE LITERATURE[a]

The literature on silos and silage is very extensive; in fact, the preservation of green forage in pits seems to have been practiced in Italy at least 150 years ago.[69*] The present review of the literature makes no pretense of covering all the investigational work on corn silage. The author has attempted to include only the more important articles having a bearing on the different phases of the present investigation but it is likely that even with this limitation of field some pertinent experiments have been overlooked.

Early Silage Practices.—When silos for storing green corn fodder first came into use in this country it was quite common to construct them inside the barn[39, 45, 94, 99, 120*] and to make them rectangular in form. Some of the silos were shallow, as judged by present building practices, and a large proportion of the silage spoiled. Hunt[45*] reports that one-third of the silage in a silo of this kind was unfit for use. There was also much uncertainty with respect to the best material for use in silo walls.[45, 94, 120*] However, the problem of materials seems to have been solved thru years of experience and experiments[21*] which have led to the adoption of a type of construction which insures rigid, air-tight walls but does not require the use of a particular kind of building material. Silos with circular walls have quite generally replaced rectangular forms, and silos have been built higher.

Corn fodder was ensiled unchopped in some cases,[39, 99, 120*] the stalks being laid close, side by side. Silage made in this way is reported[39*] to have kept well and to have been equal in feeding value to silage made from cut corn of the same variety.

The practice of ensiling corn while in immature stages of development was quite generally followed during the early years of the use of silos in this country, if the analyses reported by some of the investigators may be taken as an index. Thus Jenkins[48*] at the Connecticut Station reported 59 analyses of ensilaged maize fodder, in which the maximum content of dry matter in the samples was 35.6 percent, the minimum 13 percent, and the average 19.72 percent. Roberts and Wing[84*] at the New York (Cornell) Station reported analyses of 41 varieties of corn grown for fodder and ensilage. The 25 dent varieties had an average dry-matter content of 24.38 percent. Three samples of one variety of corn as ensiled at the Pennsylvania Station[6*] contained 19.60 to 21.12 percent dry matter, and seven varieties of fodder corn harvested at the Vermont Station[41*] on September 23 to 25 had a dry-matter content of 17.17 to 24.35 percent. Field corn silage grown at the Maine Station[51*] contained 20.4 and 22.3 percent dry matter and a sample of southern corn silage only 13.5 percent. Some crops of corn were evidently allowed to become quite mature before harvest, however, as indicated by the composition of corn at the time of ensiling or by the composition of silage.[45*]

The tendency during recent years has been to allow the corn to become more nearly mature before ensiling. The New Hampshire Station[96*] in

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[a]Prepared September, 1931.

*The superior figures with this symbol refer to literature citations, pages 120 to 124.

1923 reported analyses of silage from 17 varieties of corn. Five of the silages contained from 30 to 37 percent dry matter, and all of the remainder except one had more than 20 percent dry matter.

Trials at the Pennsylvania Station[109*] showed that "mature" silage containing 26.75 and 31.13 percent dry matter was superior to silage made from less mature corn.

Variety Tests of Corn for Silage.—One of the subjects which attracted the attention of the early investigators of the value of corn as a silage crop was the relative values of the different varieties. Altho many extensive reports have been published, this subject has continued to receive much attention in recent years. In some fields a few investigations are sufficient to establish fundamental truths, but as regards the relative values of varieties new developments have made it desirable for later investigators to repeat some of the early work. Among these developments should be mentioned: (a) the improvement of old varieties of corn; (b) the production of new varieties; (c) improvements in tillage machinery and methods of culture; and (d) better methods of combatting corn diseases. In view of these developments it is difficult to make direct comparisons of results obtained at different stations or of the results obtained at one station over a series of years. Some general deductions, however, may be made.

Tests at a number of stations have shown wide differences among varieties in yields of fresh matter. In some of these[12, 31, 52, 67, 77, 88*] it was found that the variety or varieties yielding the largest tonnage of green corn gave very little, if any, larger yields of dry matter than earlier maturing varieties. Jordan[62] conducted a study at the Maine Station covering a five-year period in which southern corn was compared with Maine field corn. Seven trials showed that the southern varieties gave an average yield of 34,761 pounds of green corn while the Maine field corn yielded 22,269 pounds. The southern corn yielded 812 pounds more dry matter but only 175 pounds more of digestible dry matter than the Maine corn. Jordan calls attention to the fact that it was necessary to handle nearly 5¾ tons more weight in the southern corn to secure a slight gain in yield of digestible nutrients. Burrill and McCluer[12*] reported that Burrill and Whitman corn produced 6½ tons more water and only ⅙ ton more dry matter per acre than Burr's White. In general it was found by several investigators[18, 53, 55, 61, 67, 74, 101*] that varieties maturing or nearly maturing grain in the section where grown are more desirable for silage purposes than the nonmaturing varieties, on account of higher feeding value or greater yields of dry matter. Judgments in favor of grain varieties were reached in a number of comparative studies[101, 121*] where the southern varieties gave larger yields of dry matter. However, some investigators[4, 31, 101*] concluded that the late-maturing varieties are the most desirable for silage on account of greater yields, and some[93*] recommended medium-maturing varieties. Some investigators[12, 18*] pointed out that a high proportion of ears adds to the feeding value of the silage.

Flint varieties grown for forage have been found[13, 16, 41, 70, 79, 80, 88, 101*] to yield smaller amounts of dry matter than dent varieties. Sweet corn likewise yields a smaller amount of dry matter than dent.[80, 88*]

In the reports of these investigations conclusions regarding the suit-

ability of particular varieties of corn for silage apparently were based in some cases[18, 36, 40, 49, 95*] entirely on yields of fresh matter, in other cases on yields of dry matter or air-dry matter. As mentioned above, several investigations have shown that the relation between yields of fresh matter and yields of dry matter is not a definite one, particularly because of the rapid increases in dry matter in the crop during the latter part of the growing season, as discussed below under "Changes in composition and yield during growth." Conclusions based upon yields of fresh matter only, therefore, are likely to be misleading.

But few field trials are reported in which specific mention is made of the inclusion of prolific types of corn in variety tests for silage purposes. Prolific types grown for grain have been found to yield more grain than single-ear types.[11*] For forage purposes, however, prolific types yielded no more dry matter than single-ear varieties,[13, 18, 31*] altho this may have been because the particular varieties of a prolific type which were grown were late-maturing and not adapted to the region.

Effect of Rate of Planting on Yields.—A large number of tests of rate of planting have been conducted. The results are not in close agreement, probably because there is an optimum rate for each variety for the particular soil, climatic and seasonal conditions under which it is grown.

Rate of planting affects not only the yield of forage but its composition[1, 63, 64, 82, 83*] and feeding value as well. Armsby[3, 4*] found that the dry matter of thick-seeded corn was 5½ percent more digestible than that of thin-seeded corn and that thick seeding gave 41 percent greater yield of dry matter. Georgeson *et al*[30*] obtained the highest yields of silage corn in rows 3½ feet apart. In these rows plants spaced 8, 12, and 16 inches apart gave almost the same tonnage yields. From these and several other trials which have been reported[17, 47, 54, 65, 73, 108*] it seems logical to conclude that, within reasonable limits, considerable variation from the optimum rate of planting can be made without greatly affecting the yields of forage.

Changes in Composition and Yield During Growth.—The composition and yield of the corn crop thruout a part or all of the growing season have been determined by a number of investigators. Altho some of these determinations were made with no reference to the use of the crop for silage, they do throw light on the problem of the best stage of development at which to harvest the crop for this purpose.

Among the pioneer investigations in this field the work of Armsby[3-7*] at the Pennsylvania Station, Babcock[8*] at the New York Station, Farrington[28*] at the Illinois Station, Frear[29*] at the Pennsylvania Station, Hornberger and Raumer[44*] in Germany, Jordan[53, 55, 57*] at the Maine Station, Ladd[63*] at the New York Station, Leplay[66*] in France, Morrow[71*] and Morrow and Gardner[72*] at the Illinois Station, Roberts[82-84*] at the New York (Cornell) Station, Schweitzer[86*] at the Missouri Station, and Whitcher[99-101*] at the New Hampshire Station, are deserving of special mention. In Armsby's experiments a number of varieties planted at different rates of seeding were used. The composition and digestibility of the forage at several stages during the latter part of the growing season were determined and the yield of digestible nutrients to the acre calculated. Jordan conducted a five-year study of varieties and determined periodically the composition

and yields of the growing crop. He also made a large number of determinations of the digestibility of different varieties of corn both as silage and as fodder and compared the coefficients with those of other feeding stuffs. Another early investigation was that of Richardson,[81*] who followed the physical and chemical changes occurring in a crop of Egyptian sugar corn grown in 1881 from the time of tasseling on July 5 until one week after the ears had formed (August 8). During this period the percentage of dry matter increased from 8.4 percent to 19.4 percent. The changes in chemical composition were essentially the same as those found by Jordan[53*] for field corn.

Studies of the composition of the corn plant during growth, conducted later by a number of other investigators[46, 50, 87, 90, 92, 98*] confirm the results of the early workers in this field. All of these studies agree very closely with respect to the changes which occur in the crop during growth, in spite of the fact that soil and climatic conditions and varieties of corn grown were different in the various states and countries. In general it was found that the water content of the crop decreases rapidly after tasseling and continues to decline up to maturity. At tasseling the plant may consist of 90 percent water, while at the stage of harvesting for silage, when kernels are dented, the water content has usually declined to 70 percent or lower.

More remarkable, perhaps, than the changes in composition is the rapid storage of dry matter by the corn crop during the last few weeks of growth, as reported by a number of investigators.[14, 15, 27-30, 46, 53, 55, 58, 59, 63, 74, 82, 84, 92, 101*] For example, Jordan[53*] found that on August 15, when the ears were beginning to form, the crop contained 3,064 pounds of dry substance, while on September 21, when all ears were glazed, it contained 7,040 pounds, an increase of 130 percent. Ladd[63*] reported a yield of 1,619 pounds of dry matter in the tasseled crop on July 30, 4,643 pounds August 21, and 7,918 pounds September 23.

The composition of the dry matter of corn changes greatly during the later weeks of development, a fact which has an important bearing upon the problems of varieties and stage at which to harvest corn for silage. The results of Babcock[8*] are typical. He found that during the period August 18 to September 23 the dry substance in the crop increased from 13.95 percent to 30.33 percent. The constituents of the dry matter likewise showed progressive changes. The ash declined from 4.75 percent to 2.98 percent, the protein from 10.30 percent to 8.95 percent, and the crude fiber from 27.44 percent to 20.17 percent. The ether extract was variable, declining and then increasing. The nitrogen-free extract, on the other hand, increased from 55.23 percent to 64.96 percent. Burrill and McCluer[12*] studied the composition and yield of the ears, stalks, and leaves and husks of two varieties used for ensilage. The ears were three to five times as high in protein as the stalks, while the leaves and husks occupied an intermediate position. The ears furnished 30 to 60 percent of protein of the crop.

Feeding Value of Varieties, Digestibility.—Armsby[4*] found that a large, late-maturing variety of corn was 3½ percent more digestible than an earlier and smaller variety which produced small ears.

Bartlett[9*] found the digestibility of the dry matter of silage from Sandford corn, containing about 20 percent dry matter, to be 75 percent,

while the coefficient for Leaming, also containing about 20 percent dry matter, was only 63 percent. Ewing and Smith[23*] determined the digestibility of corn silage fed alone and when fed in combination with other feeds. The coefficients were higher when the silage was fed alone. Ewing and Wells[24*] maintained a steer on a low plane of nutrition for 140 days, corn silage being the only feed. It was concluded that the animal did not digest its feed more completely while subsisting on this low level of nutrient intake. The same experimenters[25*] studied the associative digestibility of corn silage and other feeds. The average coefficients of 12 trials in which silage was fed alone were: dry matter, 60; nitrogen, 18; crude fiber, 66; nitrogen-free extract, 63; and fat, 28.

In a later investigation Ewing, Wells and Smith[26*] found that the nutrients of cottonseed meal and silage are not digested in the same proportions when fed alone as when fed in combinations.

Hopkins[43*] determined the digestibility of corn silage made from several varieties of corn, using four steers as experimental animals. He also tabulated the results of studies of "digestibility of corn silage by cattle as shown by all experiments made in the United States." This tabulation shows that in those cases in which two or more trials are averaged, the digestibility of the dry matter ranged from 61.7 to 65.6 percent.

Jordan[51*] determined and compared the digestibility of southern corn silage, field corn silage and field corn fodder, air dry. The southern corn silage contained 13.5 percent dry matter and the field corn silage 20 percent and 22 percent. The coefficient of digestibility of the dry matter of the southern corn silage was 64, while for the two field corn silages the coefficients were 76 and 78. The digestion coefficients of 7 samples of field corn fodder and silage fed in 17 trials shows the following average coefficients: dry matter, 72.3; protein, 65.1; fiber, 76.5; nitrogen-free extract, 75.5; and fat, 74.9. Five samples of southern corn fodder and silage fed in 12 trials gave coefficients as follows: dry matter, 64.6; protein, 59.6; fiber, 71; nitrogen-free extract, 65.2; fat, 66.3. Jordan concludes that this proves that the smaller varieties are more digestible than the large southern varieties. He also found the digestibility of a sample of sweet corn silage to be: dry matter, 68.1 percent; protein, 54 percent; fiber, 71.1 percent; nitrogen-free extract, 71.8 percent; and fat, 83.5 percent.

Jordan, Bartlett, and Merrill[56*] studied the yields and digestibility of southern corn, field corn, and sweet corn, both as fodder and as silage. The dry matter of the southern corn cured as fodder was 1.5 percent more digestible than when preserved as silage. The dry matter of the field corn fodder was about 1 percent more digestible than the field corn silage. In both the southern corn and field corn the coefficient of digestibility of the protein of the fodder was about 11 percent higher than that of the silage. The coefficient of digestibility of the dry matter of the field corn ensilage was 69.1; of the southern corn silage, 63.2; of the sweet corn fodder, 60.9; and of the sweet corn ensilage, 68.1.

Woll[111*] found the digestibility of the nutrients of sweet corn silage to be: protein, 78 percent; crude fiber, 74 percent; nitrogen-free extract, 56 percent; and ether extract, 73 percent. Woll[113-115*] also determined the digestibility of corn fodder and corn silage in a number of experiments.

When the same variety was used for both fodder and silage the coefficients for the fodder were: dry matter, 60; ether extract, 69; fiber, 56; protein, 49; and nitrogen-free extract, 65. The coefficients for the silage were: dry matter, 63; ether extract, 82; fiber, 47; protein, 54; and nitrogen-free extract, 72. The silage was therefore slightly more digestible than the fodder.

Feeding Value for Milk Production.—Bechdel[10*] used two varieties of corn for silage, harvesting each at immature, medium-mature, and mature stages. Silage made from corn at maturity proved superior in feeding value to that made at either of the other two stages.

Hayden[33*] reported briefly that silage from field corn had a slightly greater nutritive value per unit than silage from late-maturing corn.

Hayden and Perkins[34*] compared Clarage, an early maturing variety, with Blue Ridge, late-maturing. The Clarage corn was harvested about 21 days earlier and contained about 15 percent more grain on the dry basis than the Blue Ridge. As harvested, the Clarage contained only 2 percent more dry matter than the Blue Ridge, but as silage the Clarage had 3.6 percent more dry matter. The Clarage silage was about 1.4 percent higher in nitrogen-free extract and 2.4 percent lower in fiber than the other silage. The investigators computed that the five feeding trials showed the Clarage silage had a superiority over the Blue Ridge silage in feeding value of about 12.6 percent when both milk production and changes in live weight were considered.

Hays[35*] compared silages made from dent corn, southern ensilage corn, flint corn, and sweet corn as feeds for milk production. Calculated in terms of feed required to produce 1 pound of butterfat, the dent corn silage was superior to the others, but when calculated on the basis of dry matter in the silage, the dent, sweet, and southern corn silages were nearly equal in value while the flint corn silage was inferior.

Henry[37-39*] studied the relative values for milk production of varieties of corn prepared as dry fodder and as silage. Cows fed silage produced somewhat more milk. The amount of dry matter in silage fed for the production of 1 pound of butter was greater in the case of sweet corn silage than in the case of southern corn silage.

Hills[42*] fed silages made from immature frosted corn, mature frosted, and mature hard-frosted corn containing 25.3, 27.4, and 28.6 percent dry matter respectively. More dry matter was eaten when mature silage was fed, but the data showed no conclusive differences in the values of the three silages.

Porter[79*] found the dry matter of large southern corn silage nearly equal pound for pound to the dry matter of flint corn silage. For maintaining live weight of the cows, however, the flint corn silage was superior.

Short[89*] compared silage with fodder corn for milk production with the results in favor of silage.

Voorhees and Lane[97*] found the feeding value of the dry matter of silage greater than that of the dry matter of dried fodder corn, and that cows receiving silage produced 10 percent more butterfat than those not fed silage.

Whitcher[100*] fed silage from four varieties of corn to dairy cows at the rate of 50 pounds daily in addition to concentrates and dry roughage.

The dry matter of the silages ranged from 22.8 percent to 29.5 percent. Both southern and grain varieties gave satisfactory results.

A number of feeding trials in which early, medium and late varieties of corn were compared have been conducted at the Connecticut (Storrs) Station.[91, 102-106*] In the first two trials it was found that the early variety (Pride of the North) silage produced 7,078 pounds of milk per acre, the medium variety (Leaming) 7,663 pounds, and the late (Eureka) 7,527 pounds. The dry matter in the corn as harvested during three trials was 31 percent in the early variety, 25 percent in the medium, and 21 percent in the late. In the second trial the ears of the early variety contained 52 percent of the dry matter of the harvested plant; the ears of the medium variety 39 percent; and of the late variety 8 percent. The early variety was highest in feeding value per ton of silage followed by the medium, with the late variety lowest. On account of their greater yields, however, the investigators recommended the medium- and late-maturing varieties for the intensive dairy farms of the northern and northeastern states. A later feeding trial[104*] showed that the dry matter of the late-variety silage was slightly less efficient than silage from the other two varieties. Another feeding trial[105*] showed that cows fed late-variety silage so adjusted their hay consumption that their total dry-matter intake was equal to that of cows receiving medium-variety silage. The investigators concluded that the high water content of late-variety silage is not necessarily a handicap and that cows fed such silage will consume additional hay to compensate for the smaller amount of grain in the silage. Further feeding trials[106*] indicated that half the usual allowance of silage gave entirely satisfactory results for milk production.

Williams[107*] reported medium-mature corn silage superior to immature corn silage for milk production. Woll[116, 118*] concluded that corn silage and dry fodder corn are of practically equal value for milk production.

Preventing Losses at Surface of Silage.—Cooke[17] covered silage with wet straw and a 4-inch layer of wet dirt. More than 2 inches of the top layer of silage spoiled.

King[60, 61, 62*] determined the necessary losses in the silo and tried out methods for reducing the loss at the surface. He reports that in a silo in which 64 tons of corn was placed, 2,522 pounds of spoiled silage removed from the top contained 1,432 pounds of dry matter, or about 3 percent of the dry matter of the corn ensiled. The following year the total loss of dry matter in a silo in which 68 tons of corn was ensiled was over 12 percent. The silo was opened in March and 4,166 pounds of spoiled silage removed from the top. In 5 trials the total losses of dry matter in the silo ranged from 5 to 13 percent. King recommended covering with cut marsh hay or oat chaff with addition of water. With application of water and no cover, losses were 16.5 pounds of silage per square foot at the end of 80 days and 22 pounds after 180 days. He found further that "the best silage and the smallest necessary loss occurs when the silage is made from well-matured and well-eared corn, containing not less than 30 to 35 percent dry matter. If the corn is so immature as to contain only 20 percent dry matter, and especially if it has few ears, the necessary losses will be much larger when preserved either as silage or as corn fodder."

Lindsey and Smith[67*] state, "It is well known that immature corn . . . . undergoes more serious decomposition when ensiled than do well-matured varieties." Smith[92*] reported losses in the silo of 20 to 27 percent of the dry matter of corn.

Woll[117*] summarized the results of three years' work in comparing losses in field curing and ensiling corn. The losses of dry matter in the two methods were 20.3 and 20.5 percent respectively. He later[119*] concluded that this figure for losses in the silo is too high, because it was obtained with silos containing a small amount of silage. The loss in a silo containing 65 tons of silage was only 10.3 percent, which he concludes is fairly representative. He attempted to reduce the losses by applying surface coverings of tarred building paper and 8 inches of sawdust in two tanks filled with 1,622 pounds and 1,779 pounds of cut corn. The coverings weighed 113 pounds and 120 pounds respectively, or about 4 pounds per square foot. On December 10 spoilt silage to the extent of 223 pounds and 167 pounds respectively was removed from the upper portions of the silage in the two silos. Recoveries of good silage were 78 percent and 84 percent respectively.

In another experiment Woll covered the cut corn in a silo with 3,800 pounds of green millet. When feeding commenced in December 6 inches of spoiled silage weighing 3,012 pounds was removed from the top layer.

Acidity of Corn Silage.—Questions have been raised regarding the effect of acid in silage upon the health of cattle and upon the feeding value of the silage.

It has been found[2, 85*] that the sugar in corn silage disappears almost entirely and that volatile and nonvolatile acids are produced. These are chiefly acetic and lactic acids, and are present in the proportions of about .75 of the acetic to 1 of the lactic.[19*]

Studies of silage in brick, hollow tile, concrete, and wooden silos[20, 75*] showed no effects of the type and construction of the silo upon the amounts of volatile acid in the silage. The amount of acid present has been found[22*] to range in most cases from 1 to 2 percent of the weight of the silage. This is equivalent to .4 to .8 pound of acid in a day's feed of 40 pounds of silage.

Hart and Willaman[32*] determined the acidity of corn silage from November to May. The total acidity was .97 percent, of which .84 percent was volatile acid. Of the volatile acids 17 percent was formic, 75 percent acetic, 8 percent propionic, and 6 percent butyric. Traces of alcohols were reported.

Lamb[64*] pointed out that "Silage made from the immature whole plant is generally of poor consistency, too sour, too high in moisture and otherwise unsatisfactory."

Neidig[76*] determined total acidity in samples of corn containing 19 to 23.3 percent dry matter. The acid was equivalent to 5.7 to 10 percent of the dry matter, the two samples lowest in dry matter having the highest acidity. Perkins, Hayden, and Monroe[78*] compared the effect of rations containing as much as 50 pounds of silage daily with rations containing practically no acid. Cows fed over a long period on alfalfa hay, a grain mixture and silage containing approximately 1¼ pounds of lactic and acetic acids daily, did not develop acidosis. "The organic acids accompany-

ing the silage appear to have been fully metabolized and did not appear as organic acids or related compounds in the urine."

Wilson and Kuhlman[109*] found amounts of acid ranging from 2.85 percent in sweet corn silage to 3.42 percent in dent corn silage. In terms of dry matter of the silage these amounts are from 7.9 percent to 13.5 percent.

Wilson and Thompson[110*] ensiled corn in the milk stage, dough stage, dented stage, and well-matured but frosted stage during two years. The corn in the milk stage produced silage having much higher acidity than that harvested at the other stages.

Woll[112*] reported analyses of a number of samples of corn silage in which the amounts of acid were equivalent to 1.6 percent to 9.3 percent of the dry matter.

Value of Corn Cannery Refuse.—No reference to the digestibility of silage made from corn cannery refuse was found. McCandlish[68*] studied the digestibility of corn cannery refuse using two cows. Coefficients of digestibility of the dry matter were 33.2 and 30.8; of the protein, 3.5 and 11.2; of the nitrogen-free extract, 40.2 and 39.6; of the fiber, 27.5 and 21.8; and of the fat, 61.3 and 25.9.

Conclusions From Review of Literature.—Late-maturing southern varieties usually yield more green forage and sometimes more dry matter than varieties which mature grain. Often, however, they yield no more or only a little more dry matter. Prolific types yield no more forage than single-ear types. Flint corn and sweet corn yield smaller amounts of dry matter than dent varieties. Varieties which mature the grain in the more southern states may be only "medium-mature" in states farther north. The selection of the best varieties of corn for silage for a particular state or locality is a problem which must be solved under the environmental conditions of that particular region.

The rate of planting affects the yield and composition of forage corn, altho slight variations in the spacing of the plants is not reflected correspondingly in the yields. The composition of the forage is affected by rates of planting which alter the proportions of grain in the forage.

The corn crop changes greatly in composition and yield during growth, particularly during the last few weeks of development. The percentage and yield of dry matter increase rapidly. The composition of the dry matter undergoes progressive changes as the corn develops, percentages of ash, protein, and crude fiber decreasing, while the percentage of nitrogen-free extract increases very greatly.

Digestibility studies show considerable variation in the digestibility of different lots of silage. Direct comparisons of the digestibility of field corn (mature grain) silage with southern corn silage demonstrate a higher digestibility of the field corn silage. Determinations of digestibility are essential to an accurate evaluation of the nutritive values of such feeds as silages, which differ in chemical and physical composition.

Silage made from mature corn has been found to have a higher feeding value for milk production than silage from immature corn. A higher dry-matter content of the mature corn silage is chiefly responsible for its superiority, altho it may logically be assumed that the dry matter having the higher proportion of grain has a greater nutritive value.

Losses of dry matter in the silo amount to 10 percent or more. Losses of immature corn silage are greater than those of mature corn silage. A number of experiments in covering silage to prevent spoilage at the surface were only partially successful.

The acid in corn silage ranges from about 1 to 2 percent, which is equivalent roughly to 5 to 10 percent of the dry matter. Silage from immature corn is higher in acid content than that from mature corn. The acid appears to have no harmful effect upon dairy cows.

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