LEGUMES AND GRASSES FOR SILAGE

A Report of Experiments

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and K. A. Kendall

Bulletin 529 · UNIVERSITY OF ILLINOIS
AGRICULTURAL EXPERIMENT STATION

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For a popular presentation of the information gained in these experiments, see Circular 605, Grass and Legume Silages for Dairy Cattle.

Urbana, Illinois November, 1948

Publications in the Bulletin series report the results of investigations made or sponsored by the Experiment Station

LEGUMES AND GRASSES FOR SILAGE

By W. B. Nevens, K. E. Harshbarger, and K. A. Kendall[1]

ILLINOIS FARMERS find that corn (*Zea mays*) excels other farm crops for silage when they base their judgment on the ease and economy of its preservation, its keeping qualities, and its feeding value. Other important considerations, such as the adaptability of corn to crop rotations and the availability of efficient machines for its production and harvesting, also favor the use of corn as a silage crop.

But there is an increasing appreciation of the need for crops which will help to conserve our soils, will save some or all of the labor required to grow an annual crop such as corn, and will also have a higher protein content than corn. Alfalfa, the clovers, soybeans, several kinds of grasses, and mixtures of legumes and grasses are being used to meet these needs. However, to make satisfactory silage from these crops — silage which has good keeping qualities and good feeding value — requires much more care and many more precautions than the ensiling of corn.

This bulletin reports the results of experiments to determine the conditions needed to ensile successfully a number of crops other than corn. The crops used in these tests were alfalfa (*Medicago sativa*), bromegrass (*Bromus inermis*), broomcorn (*Sorghum vulgare*), oats (*Avena sativa*), sorghum (*Sorghum vulgare*), soybeans (*Soja max*), Sudan grass (*Sorghum vulgare* var. *sudanense*), and winter rye (*Secale cereale*). The experiments were conducted during the ten-year period 1936-1945. Any silage rated only fair was considered unsatisfactory.

LEGUME SILAGES

Tho alfalfa and soybean plants have many qualities that make them desirable for dairy-cattle feeding, they do not convert easily into good quality of hay. The weather is often unfavorable at harvest time. Storms may cause alfalfa to lodge and may cause a heavy loss of leaves before cutting time. Then, too, on fertile soils the spring growth is likely to be rank and have heavy stems. A rank growth of alfalfa usually means coarse hay. Curing the pods and coarse stems of soybeans takes a long time. The difficulty of getting good alfalfa and

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soybean hays has raised the question whether the crops can be harvested for silage.

Another advantage in feeding these crops as silage would be that it would cut down waste. When cattle are fed dry forage with coarse stems, they usually refuse to eat the coarsest parts. They will eat good-quality corn silage with practically no waste, but when fed dry corn fodder they refuse to eat very much of the cornstalks. The same is true of alfalfa and soybean silages; cows will eat the stems in good silage and refuse them in hay.

Alfalfa Silage

Yields of alfalfa. Alfalfa is the highest-yielding hay crop grown in Illinois. The ten-year average yield is 2.16 tons an acre, the average for all hay only 1.29 tons.[1] First cutting alfalfa on fertile soils often produces 1.5 to 2 tons of hay or 5 to 8 tons of silage. Careful field measurements, made during the first cutting of a 20-acre portion of a field on the Station farm, showed a yield of 7.5 tons of chopped alfalfa an acre.

The average dry-matter content was about 22 percent. This means the yield was approximately 3,300 pounds of dry matter an acre, a large yield for only a portion of an annual harvest. During the past ten years the average yield of dry matter in hybrid corn grown for silage on the Station farm has been more than 6,000 pounds an acre.

Experiments in making alfalfa silage.[2] Feed of poor quality often results when alfalfa is made into silage. The silage may be watery and ill-smelling, or it may be hot and fermenting. Cattle do not readily eat either kind. One of the objects of this study was therefore to determine how to make alfalfa silage of acceptable feeding value.

Experiments began with harvesting alfalfa from the same field at weekly intervals from May 27 to June 23. In all but one instance unsatisfactory silage was produced when the dry matter of the crop as ensiled was 22.6 percent or less (Table 1). Adding cane molasses increased the acid content and thus presumably the keeping qualities. In most cases, however, the silage was not of good quality. It lacked good odor and was not palatable. Sometimes the odors were very objectionable. However, alfalfa harvested after the usual first cutting

[1] *Crops and Markets*, U. S. D. A., January, 1947.

[2] Earlier experiments showed that whey powder and blackstrap molasses were effective preservatives of alfalfa silage and that their use increased the acid content. The larger the amount of preservative (applied at rates of 1 to 5 percent), the greater was the acid content. The addition of molasses increased palatability. Well-preserved alfalfa silage proved palatable but more laxative than corn silage. Jour. of Dairy Science **19**, 611-617. 1936.

Table 1. — ALFALFA SILAGE: Quality of Product as Related to Development of Crop at Harvest and Treatment of Crop When Ensiled

Stage at harvest and date of harvest	Preservatives used	Silos opened	Dry-matter content		Acidity[a]	Quality[b]
			Crop as ensiled	Silage as removed		
Crop ensiled without wilting						
			perct.	*perct.*	*perct.*	
Before buds appeared, May 27	No preservative	Aug. 12	18.6	16.4	1.08	Poor
	Cane molasses, 2.5 percent	Aug. 12	18.6	18.4	2.38	Poor
Early buds, June 1	No preservative	Aug. 12	22.6	19.5	1.54	Poor
	Cane molasses, 2.5 percent	Aug. 12	22.6	20.2	2.36	Fair
1 to 2 percent of plants in bloom, June 8	No preservative[c]	Aug. 12	22.5	19.2	1.04	Poor
	Cane molasses, 2.5 percent	Aug. 12	22.5	21.7	2.23	Fair
60 to 70 percent of plants in bloom, June 16	No preservative	Aug. 12	21.4	22.5	1.78	Good
	Cane molasses, 2.5 percent	Aug. 12	21.4	22.8	2.08	Fair
Late bloom; new shoots 2 to 4 inches high, June 23	No preservative	Oct. 14	29.4	29.0	1.56	Very good
	Cane molasses, 2.5 percent	Oct. 14	29.4	25.5	1.56	Very good
Crop slightly wilted in windrow						
Late bloom, June 25	No preservative	Dec. 30	31.8	33.1	1.90	Excellent
	Cane molasses, 2.5 percent	Sept. 14	31.8	31.9	1.29	Excellent

[a] Calculated as lactic acid. [b] Based on observation of appearance, odor, and flavor. [c] Slightly damp from rain.

stage (when new shoots had formed) and containing 29.4 percent dry matter made very good silage. In another season alfalfa ensiled with 31.8 percent dry matter was rated as excellent (Table 1). Adding molasses to silage having these higher dry-matter contents did not change the amount of acid produced as much as did the addition of molasses to alfalfa having less dry matter. It was of little apparent benefit.

During another season, when the weather was rainy and damp, a large silo was nearly filled with first cutting alfalfa. When the weather permitted, the crop was made into hay in the afternoons; in the mornings when the windrowed crop was wet with rain or dew, it was put into the silo. Tests on four days showed the dry-matter content of the crop as it went into the silo to be 34.0, 46.2, 33.3, and 42.8 percent respectively. Corn sugar molasses (Hydrol) was added at the rate of 2.5 percent (50 pounds per ton). Water was added to some of the dryest loads. When the silo was opened on July 8, the silage was hot and

actively fermenting. The alfalfa appeared to be insufficiently packed, evidently because of its dryness; and air entering the silage was causing decomposition. The silage was dark and lacked a sharp acid odor. Feeding results were poor, only small amounts of the silage being consumed.

In still another season two silos were partially filled with alfalfa that was harvested, chopped, and loaded immediately with a forage harvester. Samples of the crop taken in the field from day to day just before the crop was harvested showed dry-matter contents of 18.1, 22.0, 20.4, 21.1, 23.3, 21.3, and 23.1 percent. Samples taken from loads as the material went into the silo showed dry-matter levels 1 to 2 percent higher. About 80 pounds of cane molasses was pumped into the blower and mixed with each ton of green material as it was put into the silo.

A considerable amount of juice was lost from the first portion ensiled. Cows refused to eat several tons of silage at the bottom of this silo, presumably because this silage was too soggy. The rest of the silage kept well, had a good appearance and a pungent, acid odor. Dairy cows readily ate it. It seemed to be somewhat less palatable than corn silage.

Recommendations. The best alfalfa silage is made from a crop that contains 30 to 35 percent dry matter, tho satisfactory silage can be made from a crop that contains only 25 percent dry matter. Harvest should therefore be delayed until the dry-matter content is more than 25 percent or the crop should be wilted in the field until the dry-matter content is above 25 percent.

When a crop having a low dry-matter content must be ensiled directly from the field (that is, without wilting), adding molasses appears to be beneficial. Alfalfa crops with a high percentage of dry matter (that is, above 40 percent) do not keep well even when molasses is added.

Soybean Silage

Yield of soybean forage. The Illinois ten-year average yield of soybean hay (1935-1944) is 1.37 tons to the acre;[1] in these experiments soybeans have yielded 2 to 2½ tons of dry matter to the acre. Corn grown the same years and on the same soil types has yielded more than 3 tons of dry matter an acre. A soybean crop that produced 2.5 tons of dry matter an acre would yield 7.5 tons of silage if the crop were well matured and harvested when it contained 33 percent dry matter.

Experiments with soybean silage. One series of experiments

[1] *Crops and Markets*, U. S. D. A., January, 1947.

was made with soybeans harvested when the seed was about one-half full size and the leaves were very green. Practically no leaves had fallen. The chopped forage was ensiled with and without the addition of cane molasses (Table 2).

On the whole, the quality of the silage was substandard; compared with good corn silage, it might be rated poor. The various lots, however, showed distinct differences in quality. The untreated crop and that to which only water was added produced poor silage. In general, increased amounts of molasses caused correspondingly progressive increases in acid content. The results indicated that the crop contained too little dry matter when it was ensiled. The addition of molasses improved the keeping quality of the silage.

A second series of experiments was made when the crop had become much more mature. The leaves were still mostly green and only a few leaves had fallen. The dry-matter content was much higher. In this series of experiments (Table 2) a study was made of the use of cane molasses and of lactic-acid culture (commonly used to sour cream for buttermaking). The untreated crop made only fair silage. The

Table 2.—SOYBEAN SILAGE: Quality of Product as Related to Development of Crop at Harvest and Treatment of Crop When Ensiled

(Crop ensiled without wilting)

Preservatives used	Dry-matter content of silage as removed	Acidity[a]	Quality[b]
Seed one-half full size; leaves green; harvested September 2; silos opened December 23			
	perct.	*perct.*	
No preservative	21.5	1.21	Poor
Cane molasses, 1 percent[c]	23.5	.78	Poor
Cane molasses, 2 percent[c]	25.0	.84	Poor
Cane molasses, 3 percent[c]	25.5	1.06	Fair
Cane molasses, 4 percent[c]	25.5	1.49	Fair
Cane molasses, 5 percent[c]	26.0	1.67	Fair
Cane molasses, 6 percent[c]	25.0	1.62	Fair
Water, 10 percent	20.0	.67	Poor
Much more mature than crop harvested September 2; leaves mostly green—a few had fallen; harvested September 18; silos opened December 23			
No preservative	30.5	.66	Fair
Cane molasses, 2 percent and water, 9 percent	29.5	1.09	Fair plus
Cane molasses, 5 percent and water, 8 percent	35.0	1.52	Good
Lactic acid culture, 2 percent and water, 4 percent	32.5	1.06	Fair
Lactic acid culture, 4 percent and water, 2 percent	33.0	1.06	Fair
Lactic acid culture, 6 percent	32.5	1.08	Fair

[a] Calculated as lactic acid. [b] Based on observation of appearance, odor, and flavor. [c] Molasses diluted with equal weight of water before being applied.

molasses-treated crop had the highest acid content in this series. The silage containing 5 percent molasses was better than that containing 2 percent. The lactic-acid treatment did not produce silage of good quality. The forage to which a 4-percent and a 6-percent culture was added made little or no better silage than that to which the 2-percent culture was added.

A feeding trial showed that cows ate molasses-treated soybean silage readily. They were indifferent to the untreated silage for several days. Occasional lots of untreated soybean silage used as a check, or control, kept well and gave feeding results about on a par with that of molasses-preserved silage. Well-preserved soybean silage was consumed with practically no waste.

Recommendations. One of the requisites for good quality in soybean silage appears to be a dry-matter content of 30 to 35 percent. Special care must therefore be taken to ensile the crop when its dry matter reaches this level. Using a preservative or mixing the soybeans with another crop is also recommended. Molasses is a good preservative, but lactic-acid culture improves the quality little, if at all.

Soybean forage that has a high moisture content and is ensiled without a preservative is likely to produce foul-smelling, unpalatable silage.

SUDAN GRASS-SOYBEAN SILAGE MIXTURE

The success many dairy farmers have had in using a mixture of Sudan grass and soybeans for midsummer pasture has aroused interest in the possible value of these quick-growing crops for silage. Under central Illinois conditions the seed may usually be planted during the latter half of May and by July 10 the crop will be 18 inches or more high, the stage when pasturing may begin. While bluegrass pastures may cease growth entirely in dry seasons, the Sudan grass-soybean mixture withstands hot dry weather exceptionally well and usually makes a good yield.

Yields of Sudan grass-soybeans. Sudan grass-soybean pastures at Urbana have yielded 4,600 to 8,800 pounds of dry matter to the acre. A 40-acre field of Sudan grass-soybeans grown on the Station farm at Urbana furnished enough material to fill several large and a number of small silos. The last part of the crop, about 65 tons, was made into a stack in the field. A section of the field harvested July 16 to 18 yielded 22,000 pounds of fresh material containing 15.7 percent dry matter, or about 3,400 pounds of dry matter to the acre. The rest

of the field, harvested August 13 to 24, yielded 12 to 13 tons of fresh material containing 25.4 to 28.8 percent dry matter, or more than 6,000 pounds of dry matter per acre.

Experiments in making Sudan grass-soybean silage. One part of the crop on the 40 acres referred to above was harvested July 17, when the first series of small silos was filled with the forage. The crop, cut in the early heading stage, was wilted for three hours in small windrows and harvested with a forage harvester which chopped the forage in the field. The rest of the crop, harvested August 13 to 24, was ensiled without wilting. On August 14 seven small silos were filled with silage given various treatments. For details of the results see Table 3.

In all but one case the silos filled July 17 and opened December 30 contained silage which was rated good or better. The silage treated with 3 percent of molasses was given the best rating. Some discrepancies in the data remain unexplained. For example, the silage to which 4 percent of ground oats was added made only "fair" silage and was not as good as the untreated silage. The addition of 1 percent of ground corn did not give as good results as the addition of ground oats. It is possible that the silage in these cases was poorer than expected because the material added was not thoroly mixed with the forage or that as the silos were being filled the material was not packed tightly enough to keep out the air.

Of the seven silos filled August 14, when the crop was fully headed and contained 26.2 percent dry matter, only three contained silage that was rated good or very good. The silage made from the crop at this stage was, on the whole, unsatisfactory.

In general, the Sudan grass-soybean crop harvested at an early stage of development and ensiled after being slightly wilted made better silage than that part of the crop ensiled without wilting when the crop had reached an advanced stage of development. The silage in the small silos was similar in quality to the silage produced in the large silos. The large and small silos were filled at the same time, the silage from the large ones being used for herd feeding.

The forage that was used to fill the large silo in July had been slightly wilted and treated with 3 percent of corn molasses (60 pounds per ton). It produced good silage, which cattle readily ate (Table 4). It was a bright yellow-green and had a pleasant odor. The forage ensiled in large silos during August when the crop was nearly mature made dark brown silage. The cattle ate it much less readily than the silage made in July. Tho the forage had been treated with 3 percent of

corn molasses and the silage had a pleasant aroma, it tended to remain warm, with indications that, except in the coldest weather, some fermentation was taking place. The stacked silage made without molasses was not as good as that in the silos. When the stack was opened for feeding (October 26), the silage was found to be warm. There was little

Table 3. — SUDAN GRASS-SOYBEAN SILAGE: Quality of Product as Related to Development of Crop at Harvest and Treatment of Crop When Ensiled

(Preservative added at time of ensiling)

Preservatives used	Dry-matter content		Acidity[a]	Quality[b]
	Crop as ensiled	Silage as removed		
Crop wilted three hours in windrow; harvested when crop was in early heading stage; harvested July 17; silos opened December 30				
	perct.	*perct.*	*perct.*	
No preservative	17	15.9	1.76	Good
Dried beet pulp, .75 percent	17	17.2	1.37	Good
Dried beet pulp, 1.5 percent	17	14.7	1.25	Good
Ground oats, 2 percent	17	17.4	1.55	Good
Ground oats, 4 percent	17	21.9	1.27	Fair
Ground corn, 2 percent	17	16.2	1.59	Good
Ground corn, 4 percent	17	18.2	1.58	Very good
Corn molasses, 2 percent	17	14.9	1.55	Very good
Corn molasses, 3 percent	17	14.1	1.48	Excellent
Crop ensiled without wilting; harvested when crop was fully headed from same field and in same season; harvested August 14; silos opened December 30				
No preservative	26.2	21.1	.05	Spoiled; moldy
Ground oats, 1 percent	26.2	30.2	1.46	Fair
Ground oats, 2 percent	26.2	30.8	1.32	Fair
Ground corn, 1 percent	26.2	24.3	.89	Poor; musty
Ground corn, 2 percent	26.2	31.5	1.46	Good
Corn molasses, 1 percent	26.2	27.6	1.50	Good
Corn molasses, 2 percent	26.2	29.5	1.53	Very good
Crop ensiled without wilting; chopped in field with a forage harvester; harvested another season from part of a pasture that had been little grazed; harvested August 8-9 when Sudan grass plants were fully headed and soybeans had small pods; silage sampled December 19-February 2				
No preservative[c]	26.9	28.7 29.6	1.54 1.41	Fair
Cane molasses, 2 percent[c]	27.1	26.4 25.5 27.4	1.28 1.46 1.48	Good
Cane molasses, 4 percent[c]	28.9	23.8 25.8	1.19 1.23	Good
Ground corncobs, 10 percent[d]	26.5	31.3 29.8	1.28 1.32	Fair
Ground corn, 10 percent[d]	25.5	29.0 29.0	1.32 1.24	Fair

[a] Calculated as lactic acid. [b] Based on observation of appearance, odor, and flavor. [c] Used in a feeding trial. [d] Stood on wagon overnight and showed some fermentation at time of ensiling.

spoilage except at the corners and around the bottom of the stack where some of the silage from the sides had slipped down. The silage was dark brown and had a pleasant aroma but practically no acid odor or taste. It remained hot thruout the time it was fed (about a month), and as it was removed from the stack, it gave off a steamy vapor.

Table 4. — ACID CONTENT OF SUDAN GRASS-SOYBEAN SILAGE: Treated and Untreated with Corn Molasses

Treatment, location, and preservative used	Date of sampling	Dry-matter content	Acidity[a]
		perct.	*perct.*
Unwilted; untreated; stacked in field	October 31	26.7	.27
Unwilted; untreated; stacked in field	November 10	28.5	.86
Wilted slightly; 3 percent corn molasses added; ensiled at barn	January 15	18.9	1.46
Unwilted; 3 percent corn molasses added; ensiled at barn	January 15	28.9	.80
Wilted slightly; 3 percent corn molasses added; ensiled at barn	January 21	19.2	1.13
Unwilted; 3 percent corn molasses added; ensiled at barn	January 21	25.6	1.12
Wilted slightly; 3 percent corn molasses added; ensiled at barn	February 22	19.7	1.46
Unwilted; 3 percent corn molasses added; ensiled at barn	February 22	28.7	1.87
Wilted slightly; 3 percent corn molasses added; ensiled at barn	April 10	23.3	1.14

[a] Calculated as lactic acid.

These results indicate two things: first, the desirability of harvesting the Sudan grass-soybean crop for the silo at an early heading stage; second, adding molasses improves the keeping quality of the silage and its palatability.

Five wood-stave silos were filled in August with Sudan grass-soybeans. The forage was harvested from a portion of a pasture which had been grazed only a little. Some Sudan plants were 8 feet tall and were fully headed. The soybean plants were 3 to 4 feet high and carried small pods. The proportion of soybeans to Sudan grass was large. Details concerning the treatment of the silage are given in Table 3.

Adding cane molasses, ground corn, or ground corncobs appeared to improve the acid content or general appearance of these lots of silage little if at all. In fact, adding ground corncobs or ground corn seemed to make the silage too dry and to lower its palatability. The acidity of the untreated silage was as high as that of the treated silage (Table 3). The acid content of the good corn silage used in the feeding trial described below was 1.42 and 1.46 percent, respectively, when sampled in December and January.

Feeding value of Sudan grass-soybean silage. The silage from the five silos was used in a feeding trial conducted under the double-reversal plan from December 15 to February 8. Six dairy cows produc-

ing 34 to 47 pounds of milk per head daily at the beginning of the trial were used, and the milk-producing value of Sudan grass-soybean silage was compared with that of corn silage. The amounts of corn silage which it was found the cows would consume readily and with little waste were used to determine the amounts of both kinds of silage to feed during the trials. The smallest amount that any cow in the trial ate was 23 pounds daily, the largest amount, 30 pounds daily. Each cow was fed at her predetermined level thruout the trial. The cows were likewise fed hay at their predetermined levels except that during the first week of the trial some slight adjustments were necessary.

It is assumed that with this plan of feeding, the amounts of silage refused (orts) represent the relative palatability of the different kinds of silage fed. A summary of the results is shown below.

Kind of silage	Number of cows	Silage fed per cow daily	Silage orts[a]	Feed consumed per cow daily			Test of milk	Milk yield daily per cow[b]
				Silage	Hay	Grain mixture		
		lb.	*perct.*	*lb.*	*lb.*	*lb.*	*perct.*	*lb.*
Sudan grass-soybean	6	27.3	10.8	24.3	14.9	10.0	3.78	32.4
Corn	6	27.3	3.2	26.5	14.8	10.0	3.79	33.2

([a] After correction to the same dry-matter content as that of the silage fed. [b] Yields corrected by the Gaines formula, a formula used to equate the milk production of cows and make a comparison of yields possible. The formula is: FCM = .4×milk (in pounds) + 15×fat (in pounds).)

The cows ate about 8 percent less Sudan grass-soybean silage than corn silage and, during the period when Sudan grass-soybean silage was fed, produced about 3 percent less milk. During the trial the cows were weighed on three successive days every two weeks. During the time they were fed Sudan grass-soybean silage, they made a total gain of 81 pounds; while they were on corn silage, they made a total gain of 91 pounds. But this difference in gain is too small to be significant. The silage orts were weighed daily and calculated to the same dry-matter basis as the silage fed. The determinations indicate that corn silage was more palatable than Sudan grass-soybean silage. There were more orts from the silage treated with ground corn and ground corncobs than from the other three lots of Sudan grass-soybean silage, thus showing poorer results from the corn and corncob treatments.

Recommendations. These experiments indicate that a somewhat immature Sudan grass-soybean crop makes better silage than a crop at an advanced stage of development. Also silage treated with molasses is usually better than that not treated.[1] The Sudan grass-soybean silage

[1] The experiments reported here were carried out with common Sudan grass. Investigations now under way with sweet Sudan grass indicate that silage with better keeping quality can be made from it than from the common variety.

fed in these experiments, however, was not of as good quality as that desired for dairy cattle feeding. It was inferior in acidity, appearance, odor, and palatability to the corn silage that was fed in comparison with it.

GRASS SILAGE

Bromegrass Silage

Yield of bromegrass. To determine the yield of bromegrass, two pastures, manured annually, were sampled during April, May, and June for five years, 1941-1945. The five-year average yield was about 3,000 pounds of dry matter an acre. This figure represents the amount of forage that might have been harvested from these fields during the latter half of June had they not been pastured. When on June 10 three small silos were filled with bromegrass to furnish silage for a feeding trial, the yield per acre was 7,670 pounds of green material containing 34 percent dry matter, or about 2,600 pounds of dry matter to the acre.

Experiments with bromegrass silage. One of the essentials of making bromegrass silage of good quality seems to be a suitable dry-matter content. Ensiling bromegrass having too low a dry-matter content resulted in some silage of poor quality. When a crop was harvested two weeks after it had headed out, the forage put into the silo while still damp from rain contained only 22.1 percent of dry matter (Table 5), but samples of this crop taken earlier showed the true dry-matter content to be about 30 percent. Some of this forage made poor silage. Tho the acid content was good, only the silage to which 6 percent of cornmeal and that to which 3 percent of molasses was added was rated good in appearance, odor, and flavor. The addition of 3, 4, 5, and 6 percent of cornmeal to a crop harvested two weeks after heading caused progressive increases in the dry-matter content of the silage.

Ensiling bromegrass that was too high in dry matter likewise resulted in some silage of poor quality. Bromegrass containing more than 35 percent of dry matter was not so easily made into good silage as that containing less than 35 percent. The silage in the three silos filled on May 29 with an unwilted crop containing 30.6 percent dry matter was good. Only one of the silos filled the same day with a wilted crop (41 and 47.8 percent dry matter respectively) contained good silage. Adding cornmeal to these crops was of only slight value; adding molasses was distinctly beneficial.

Feeding value of bromegrass silage. To compare the feeding value of bromegrass and corn silage, a reversal-plan feeding trial was

Table 5. — BROMEGRASS SILAGE: Quality of Product as Related to Development of Crop at Harvest and Treatment When Ensiled

Treatment of crop	Preservatives used	Dry-matter content		Acidity[a]	Quality as observed[b]
		Crop as ensiled	Silage as removed		
Crop well headed; harvested May 29; silos opened July 31					
		perct.	*perct.*	*perct.*	
Ensiled without wilting..	No preservative.....	30.6	27.2	.81	Good
	Corn meal, 8 percent.....	30.6	35.1	1.33	Good
	Cane molasses, 2 percent...	30.6	30.0	1.55	Very good
Cured in field 3 hours....	No preservative.....	41.0	38.3	.91	Flat
	Corn meal, 8.7 percent.....	41.0	43.4	1.33	Fair
Cured in field 4 hours...	No preservative.....	47.8	44.7	.74	Flat
	Corn meal, 8 percent.....	47.8	53.3	1.01	Fair
	Cane molasses, 2.5 percent..	47.8	41.7	1.11	Good
Two weeks after heading; harvested June 4; ensiled while still damp from rain; silos opened July 31					
Ensiled without wilting..	No preservative.....	22.1	21.9	1.17	Fair
	Corn meal, 3 percent.....	22.1	23.5	1.08	Poor
	Corn meal, 4 percent.....	22.1	25.9	1.19	Poor
	Corn meal, 5 percent.....	22.1	26.4	.98	Fair
	Corn meal, 6 percent.....	22.1	29.6	1.31	Good
	Cane molasses, 2 percent...	22.1	23.0	1.31	Fair
	Cane molasses, 3 percent...	22.1	25.1	1.37	Good
Seed in milk stage; harvested June 10; silos opened August 13					
Ensiled without wilting..	No preservative.....	34.1	33.7	2.50	Good
Cured in field 2 hours....	Corn meal, 10 percent.....	38.8	39.5	1.23	Good
Cured in field 4 hours....	Cane molasses, 2.25 percent	43.6	38.3	1.15	Very good
Late bloom; harvested June 16; silos opened August 12					
Ensiled without wilting..	No preservative.....	29.1	30.3	1.86	Very good
	Cane molasses, 3 percent...	29.1	28.8	1.12	Very good
Past bloom; harvested June 23; silos opened October 14					
Ensiled without wilting..	No preservative.....	34.3	32.3	1.21	Good
	Cane molasses, 3 percent...	34.3	34.0	1.52	Very good

[a] Calculated as lactic acid. [b] Based on observation of appearance, odor, and flavor.

conducted with eight cows from August 15 to September 24. Bromegrass silage from the three silos filled June 10 was fed. The weather was hot and the cows had less appetite than during cold weather. They would not eat as much bromegrass silage as corn silage, but they ate the bromegrass silage treated with molasses more readily than the untreated or that treated with cornmeal. On corn silage the cows ate somewhat more and produced a little more milk than they did on bromegrass silage, as shown by the figures at the top of the next page.

Kind of silage	Number of cows	Silage fed per cow daily	Silage orts[a]	Feed consumed per cow daily			Test of milk	Milk yield daily per cow[b]
				Silage	Hay	Grain mixture		
		lb.	*perct.*	*lb.*	*lb.*	*lb.*	*perct.*	*lb.*
Bromegrass	8	22.6	16.3	18.9	15.0	10.7	3.29	33.1
Corn	8	23.0	1.3	22.7	14.8	10.7	3.21	34.0

([a] After correction to the same dry-matter content as that of the silage fed. [b] Yields corrected by the Gaines formula, a formula used to equate the milk production of cows and make a comparison of yields possible. The formula is: FCM = .4 × milk (in pounds) + 15 × fat (in pounds).)

The eight cows lost a total of 10 pounds on bromegrass silage and gained 20 pounds on corn silage, but these changes in weight have little, if any, significance.

Recommendations. It appears practicable, from these experiments, to harvest bromegrass for silage when it contains 30 to 35 percent dry matter. Wilting the crop to increase the dry-matter content beyond 30-35 percent is no advantage. Ensiling the crop while it is wet from rain may be harmful. Bromegrass silage with satisfactory keeping qualities can be made without a preservative, but adding cane molasses increases its palatability.

Broomcorn Silage

Broomcorn is one of the tall-growing members of the sorghum family. Its special characteristic is a spreading, drooping head or brush, 18 to 24 inches long, which, after the seed is removed, is dried and used in the manufacture of house brooms. At the time the brush is harvested, the plant is still green (contains a large amount of moisture). The remaining forage is therefore suitable for silage. Whether it can be so used depends on whether a way of making it into satisfactory silage can be found. Broomcorn is not ordinarily used as livestock feed, however, because of its supposedly poisonous properties and its lack of palatability.

Acreage and yields of broomcorn. During the ten years 1933-1942 the average yearly acreage of broomcorn in Illinois was 37,000 acres, or approximately one-eighth of the total acreage in the United States.[1] The yield per acre in Illinois was somewhat above average, so that during this period the production of broomcorn brush in this state was actually one-fifth of the total crop.

The forage which remains after the brush has been harvested may equal the ordinary yield of dent corn grown for silage. In east-central Illinois, where most broomcorn produced in the state is grown, brush harvest normally comes in August and the early part of September.

[1] *Crops and Markets*, U. S. D. A., January, 1945.

If the forage is removed immediately after brush harvest and normal rainfall follows, new shoots may come up from the stubble and a second crop of forage be produced equal to a third or more of the first crop.

Yields of broomcorn forage were determined in a number of seasons. Except in one season when the forage was harvested for the silo, representative samples were taken from the standing crop. Each sample comprised 8.25 linear feet of row. These samples were harvested and weighed at once and subsampled for dry-matter tests. Sometimes the length of each plant in the sample was measured. These tests showed that broomcorn has many of the yield characteristics of corn. The dry-matter content and yield per acre increase rapidly after the crop nears the harvest stage; in fact, the percentage of dry matter may soon become so high that the forage is no longer in a good stage for best preservation as silage.

Samples harvested on August 9 and 13, while the brush was still immature, ranged in dry matter from 16.7 to 22.6 percent, a level usually too low for good silage (Table 6). By August 22 the dry-matter content had reached a suitable silage stage (about 28 percent), but a month later the forage appeared too dry. Because the stalks are hard and fibrous, broomcorn forage seems to require a moisture content higher than that of corn if the silage is to keep well.

In some instances fresh-matter yields were more than 15 tons and dry-matter yields 4 tons or more. The White Italian variety matures later, grows larger, and yields more forage than the Black Spanish. The season the crop was harvested for silage the rainfall was less than

Table 6. — YIELDS OF BROOMCORN VARIETIES: Fresh and Dry Matter; Various Harvest Dates

(Yields determined by sampling)

Variety and date of harvest	Dry matter in crop or forage[a]	Yield per acre[a]	
		Fresh matter	Dry matter
	perct.	*tons*	*tons*
Black Spanish, Aug. 9	19.5	13.2	2.57
White Italian, Aug. 9	16.7	14.3	2.44
Black Spanish, Aug. 13	22.4	15.6	3.48
White Italian, Aug. 13	22.6	19.5	4.40
Black Spanish, Aug. 22	28.5	11.7	2.79
White Italian, Aug. 22	27.9	15.8	3.68
Black Spanish, Aug. 27	30.1	13.1	3.94
White Italian, Aug. 27	27.8	16.8	4.65
Black Spanish, Sept. 20	32.3	10.4	3.37
White Italian, Sept. 20	34.4	14.1	4.84

[a] The yields reported for August 9 and 13 included the brush; on the other dates the yields are for harvested forage after removal of the brush.

Table 7. — YIELDS OF BROOMCORN VARIETIES: Yield of Main Crop Determined When Harvested for Silage; Yield of Second Growth Determined by Sampling

Variety	Size of plot	Acre-yield, fresh basis	Dry-matter content	Acre-yield, dry matter
MAIN CROP: Entire plot harvested for silo, August 8-9; Austrian and Black Spanish harvested without brush; Dwarf and White Italian harvested with brush because crops too immature to separate brush				
	acres	*tons*	*perct.*	*tons*
Austrian	.2	11.2	24.2	2.7
Black Spanish	1.2	8.5	23.4	2.0
Dwarf	.2	9.5	22.2	2.1
White Italian	1.2	13.7	22.7	3.1
SECOND GROWTH: Harvested October 19; included brush; yields determined from three samples of each variety, each sample consisting of 8.25 linear feet of row				
Austrian	.2	10.2	19.8	2.0
Black Spanish	1.2	8.4	17.5	1.5
Dwarf	.2	4.5	20.1	.9
White Italian	1.2	7.8	17.0	1.3

Table 8. — TWO BROOMCORN VARIETIES: Proportion of Harvested Crop Formed by Heads (Brush) and by Forage

Variety	Date of sampling	Number of plants in sample	Length of plants after harvesting	Dry matter in samples		Yield per acre				
						Fresh matter		Dry matter		
				Heads	Forage	Heads	Forage	Heads	Forage	Total
			ft.	*perct.*	*perct.*	*tons*	*tons*	*tons*	*tons*	*tons*
Black Spanish	Aug. 19	34	9.4	40.0	29.3	2.4	11.8	.97	3.47	4.44
White Italian	Sept. 1	29	10.8	37.8	30.5	2.3	15.2	.85	4.63	5.48
Kansas Orange[a]	Sept. 1	24	8.1	43.7	39.3	2.3	15.6	.99	6.14	7.13

[a] Variety of sorgo grown on adjoining plot for comparison.

normal and yields were therefore smaller than in other seasons. Four varieties gave acre-yields of 8.5 to 13.7 tons of fresh matter and 2 to 3.1 tons of dry matter (Table 7). The Dwarf produced much less forage than the other varieties.

After the field was harvested for the silo, the new shoots from the stubble produced a second growth 5 to 6 feet high. This second growth, including immature brush, yielded .9 to 2 tons of forage to the acre (dry-matter basis). The total dry-matter yields of the two broomcorn harvests (2.9 to 5.1 tons per acre) are about as large as the average dry-matter yields of hybrid corn (2.6 to 4.3 tons per acre) grown for silage the same season.[1] In a normal season Black Spanish and White

[1] Illinois Agricultural Experiment Station, Bulletin 494, *Yields of Corn Hybrids Harvested for Silage,* Table 8, p. 405.

Italian gave considerably higher yields than in previous tests during a season of low rainfall, but even these high yields were less than that of Kansas Orange sorgo (Table 8).

Characteristics of broomcorn. The rate at which dry matter in a crop develops is of considerable importance to any study of the suitability of a crop for silage. One of the desirable characteristics in a crop to be used for silage is that it remain at a suitable dry-matter stage for silage harvest for a long time so that, even tho stormy weather or other difficulties may delay cutting, the crop can still be harvested in good condition. A study of the dry-matter content of broomcorn showed that its forage reaches the stage for silage earlier in the season than dent corn and that the percentage of its dry matter increases rapidly at a rate similar to that in corn. The dry-matter content of the heads advances more rapidly than that of the forage. These conditions are similar to those in the corn plant at the silage stage, when the ears are usually higher in dry matter than the stalks or leaves.[1]

The brush of broomcorn is undesirable in silage unless the crop is harvested at a very immature stage. Mature or nearly mature brush often passes thru the harvesting machinery with little cutting, and its tough, wiry consistency makes the silage unpalatable. A study of four varieties of broomcorn at the stage for silage harvest revealed that the brush or heads of the plants form less than 20 percent of the total crop (Table 9). The yield of forage that remains after the brush is

Table 9. — BROOMCORN VARIETIES: Crop Characteristics at Time for Silage Harvest

Variety	Height of plants[a]	Part of crop formed by—		
		Brush	Stalks	Leaves
	ft.	*perct.*	*perct.*	*perct.*
Austrian	9.8	16	67	17
Black Spanish	8.8	18	66	16
Dwarf	5.6	12	63	25
White Italian	9.1	11	70	19

[a] Average of 25 plants of each variety.

removed is still large enough to justify harvesting it for feeding. In the same study the stalks of the four broomcorn varieties formed 63 to 70 percent of the total crop and the leaves only 16 to 25 percent (Table 9). In corn at the silage stage the stalks form only 20 to 25 percent of the total crop and the leaves 28 to 35 percent.[2]

[1] Illinois Agricultural Experiment Station, Bulletin 494, Table 8. [2] Tables 8 and 11-17 of Bulletin 494.

Experiments in making broomcorn silage. Broomcorn silage is not as readily preserved and does not make silage of as good feeding value as corn. Several experiments were conducted to study different methods of preserving the forage and to test its feeding value.

Broomcorn was grown in drilled rows 3.5 feet apart and cultivated like corn. Trials were conducted in a number of seasons, the most extensive tests being made in a dry season when four varieties were studied. On August 8 and 9 the field was harvested and most of the forage put into one silo. At that time the four varieties were at the stages of development described in Table 7.

Cane feeding molasses (blackstrap) and ground shelled corn were added to portions of the silage. The layers that received the various treatments were separated by boards.

Feeding value. The comparative milk production values of broomcorn and of corn silages were studied in feeding trials with dairy cows. The double-reversal plan was used. During the preliminary feeding period the amounts of silage that the cows would eat with little waste were determined and those amounts fed in the trial. The cows ate corn silage readily. They ate the broomcorn silage less readily, probably because of the hard, sharp, splinter-like pieces of stalks which did not become soft even after several months in the silo. Because the cows ate relatively low amounts of broomcorn silage, they were fed large amounts of hay to enable them to maintain good milk yields. Nevertheless, milk production was not as well maintained when broomcorn silage was fed as when corn silage was fed, as the yields in the table below show. The cows gained an average of .17 pound during the feeding of broomcorn silage and .85 pound during the feeding of corn silage, the animals being weighed on three consecutive days at the beginning and end of the experimental feeding periods.

Kind of silage	Number of cows	Silage fed per cow daily	Silage orts[a]	Feed consumed per cow daily			Test of milk	Milk yield daily per cow[b]
				Silage	Hay	Grain mixture		
		lb.	*perct.*	*lb.*	*lb.*	*lb.*	*perct.*	*lb.*
			Trial 1					
Broomcorn	4	21.1	18.0	17.3	22.0	13.9[c]	3.61	34.4
Corn	4	24.0	0	24.0	22.0	13.9[c]	3.72	35.4
			Trial 2					
Broomcorn	17	24.4	15.2	20.7	17.5	10.3	3.71	36.3
Corn	17	24.3	1.7	23.9	17.2	10.3	3.71	38.3

[a] After correction to the same dry-matter content as that of the silage fed. [b] Yields corrected by the Gaines formula, a formula used to equate the milk production of cows and make a comparison of yields possible. The formula is: FCM $=.4\times$milk (in pounds) $+15\times$fat (in pounds). [c] Includes 3 pounds of dried beet pulp.

The high fiber content of broomcorn silage, its hardness and rigidity, and the results of the feeding tests lead to the supposition that broomcorn silage is lower in digestibility and in total digestible-nutrient content than corn silage. The feeding value of broomcorn silage must therefore be rated as only fair.

Chemical composition. Random samples of the silage, silage orts, and hay and grain mixtures fed to cows during the feeding trial were collected several days each week. After drying, the samples were composited and submitted to analysis. Acid content was determined on fresh silage.

The broomcorn silage contained less acid than the corn silage (Table 10). The poorer keeping qualities and less pronounced acid odor and taste also indicated an acid content lower than that of corn silage. The broomcorn silage contained much more fiber than the corn silage fed. The protein and ether-extract content of the broomcorn and the corn silage were much alike, but the ash content of the broomcorn silage was higher than that of the corn silage. The fiber content of the orts was higher than that of the silage from which they came. The fact that cows normally refuse the coarser portions of their feed explains this difference.

Table 10. — BROOMCORN SILAGE FEEDING TRIALS: Dry-matter and Acid Content of Single Samples and Composition of Composite Samples

Samples	Dry-matter content as fed	Acidity in fresh silage	Composition of dry matter			
			Protein	Ether extract	Fiber	Ash
Broomcorn	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*	*perct.*
Austrian, ground corn, 10 percent	24.0	1.55	...	...	....	...
Dwarf, no preservative	19.0	1.16	...	...	....	...
White Italian, no preservative	21.1	....	...	...	....	...
White Italian, cane molasses, 2.5 percent	20.1	1.45	...	...	....	...
White Italian, cane molasses, 5 percent	20.3	1.50	...	...	....	...
Black Spanish, no preservative	18.9	1.27	...	...	....	...
Black Spanish, cane molasses, 2.5 percent	19.9	1.92	...	...	....	...
Black Spanish, cane molasses, 5 percent	21.5	1.51	...	...	....	...
Corn						
No preservative	27.8	2.28	...	...	....	...
Broomcorn and corn silage, composite samples						
White Italian, 7 samples, all treatments, second trials	20.4	....	8.2	2.0	34.9	7.0
White Italian, 7 samples, all treatments, first trials	29.4	....	4.6	1.4	37.4	7.2
Black Spanish, 4 samples, all treatments, second trials	19.1	....	7.5	1.7	33.9	8.7
Black Spanish, 4 samples, all treatments, first trials	30.7	....	4.6	1.4	35.0	8.2
Corn, no preservative, 9 samples	28.6	....	8.2	2.6	21.5	5.3
Orts, composite samples						
Broomcorn, 8 samples, all varieties and all treatments	24.4	....	7.8	...	35.6	...
Corn, no preservative, 8 samples	35.5	....	6.6	...	29.5	...

Effect of treatment on keeping quality. At the time the large silo was filled with broomcorn forage, August 8 and 9, several small silos were also filled. Cane feeding molasses (blackstrap) and ground corn were mixed with the chopped forage and placed in some of the silos. Untreated forage was ensiled as a check. When the silos were opened on November 28, observations were made of the silage and samples for acidity determinations were taken (Table 11).

Table 11. — BROOMCORN SILAGE: Quality of Product as Related to Development of Crop at Harvest and Treatment When Ensiled

(Crop ensiled without wilting, August 8-9)

Preservatives used	Dry-matter content		Acidity[a]	Quality[b]
	Crop as ensiled	Silage as removed		
AUSTRIAN: Uneven in development; lacked 5 to 7 days of being ready for brush harvest; brush discarded				
	perct.	*perct.*	*perct.*	
No preservative	24.2	21.8	1.21	Fair
Cane molasses, 5 percent	24.2	23.8	1.44	Good
Ground corn, 10 percent	24.2	26.5	1.36	Good
BLACK SPANISH: Within three or four days of being ready for brush harvest; leaves brown; brush discarded				
No preservative	23.4	21.7	1.47	Fair
Cane molasses, 2.5 percent	23.4	22.0	1.31	Fairly good
Cane molasses, 5 percent	23.4	21.1	1.37	Good
DWARF: Leafy and green; heads about three-fourths matured; brush included				
No preservative	22.2	18.8	1.45	Fair
Cane molasses, 5 percent	22.2	21.5	1.45	Fair
Ground corn, 10 percent	22.2	23.2	1.37	Fairly good
WHITE ITALIAN: Immature; lacked 10 to 14 days of being ready for brush harvest; brush included				
No preservative	22.7	19.5	1.32	Poor to fair
Cane molasses, 2.5 percent	22.7	19.2	1.33	Fair
Cane molasses, 5 percent	22.7	19.9	1.51	Fairly good

[a] Calculated as lactic acid. [b] Based on observation of appearance, odor, and taste.

None of the silos contained silage that could be rated excellent. Adding molasses appeared to improve the quality of the silage slightly. The molasses-treated silage had a better odor than the untreated. Adding corn increased the dry-matter content of the silage slightly and thus its keeping quality. Neither the molasses nor the corn caused as much improvement in the quality of the silage as might be expected, probably because the crop was too low in dry matter when it was put in the silo.

Recommendations. The heads or brush of broomcorn are wiry and tough and, as a rule, should not be included in the silage. The forage is best ensiled at once after removal of the brush at the usual brush harvest stage or when the forage (minus the brush) has reached a dry-matter content of 28 to 30 percent. Cutting into short lengths with a machine equipped with sharp knives is recommended. Molasses applied at the rate of not less than 50 to 75 pounds per ton, or another suitable preservative, is needed for good keeping and palatability.

Oat Silage

Oats, customarily a grain crop on dairy farms, may be pastured or harvested for hay or silage. They make an excellent nurse crop for new seedings of legumes and grasses. Removing the oat forage for hay or silage a few weeks before the crop would normally mature the grain sometimes conserves the moisture in the soil and thus gives the legume or grass seeding a better opportunity for growth than it has when the oats are permitted to mature.

Experiments with oat silage. A 4.5-acre field was seeded in March to oats and a mixture of legumes and grasses. The oats were harvested June 30 to July 2, when the grain was in the soft-dough stage (average dry-matter content of crop was 24.8 percent). They were harvested with a field chopper which left stubble 6 to 8 inches high. The yield was 6.1 tons of green forage, containing 3,020 pounds of dry matter an acre. As the chopped forage was blown into a large silo, about 50 pounds of cane molasses per ton was added.

A small area was left standing and harvested for the filling of small metal containers. A portion of the chopped forage was ensiled in these containers without wilting (dry-matter content 26 percent) and another portion after wilting for two and one-half hours (dry-matter content 35 percent) (Table 12).

The main portion of the crop ensiled in the large silo was fed during the latter part of August and the first part of September. The quality of the silage was fair to poor. Most of it was slightly above atmospheric temperature and portions were hot. Small isolated moldy areas occurred thruout. The acid and dry-matter contents (1.69 percent lactic acid and 24 percent dry matter), however, seemed satisfactory for good keeping. It appeared that either not enough molasses was added, or that the molasses, which was thick and applied undiluted, had not been well distributed thru the silage. It is also possible that the silage did not become packed solidly enough to force out the air.

Table 12. — OAT SILAGE: Quality of Product as Related to Treatment of Crop When Ensiled

(Crop harvested at soft dough stage, June 30-July 2)

Preservatives used	Dry-matter content		Spoilage[a]	Acidity[b]	Quality[c]
	Crop as ensiled	Silage as removed			
Crop ensiled without wilting					
	perct.	*perct.*	*perct.*	*perct.*	
No preservative	26.1	27.3	60	1.64	Poor
Cane molasses, 2 percent	26.1	25.5	38	2.04	Good
Cane molasses, 4 percent	26.1	26.5	..	1.89	Good
Urea, .5 percent	26.1	22.2	51	.70	Poor to fair
Urea, .75 percent and cane molasses, .75 percent	26.1	23.1	35	.54	Poor to fair
Urea, 1.5 percent	26.1	24.4	29	.94	Poor to fair
Sodium sulfate, .3 percent	26.1	24.1	30	1.69	Fair
Sodium sulfate, .6 percent	26.1	26.3	..	1.59	Good
Ammonium carbonate, .3 percent	26.1	24.2	40	1.59	Poor
Ammonium carbonate, .75 percent	26.1	24.2	43	.97	Fair
Crop wilted two and one-half hours					
No preservative	35.3	36.4	36	1.89	Good
Molasses, 2 percent	35.3	35.9	38	1.89	Good
Molasses, 4 percent	35.3	35.4	22	2.04	Fair
Urea, .5 percent	35.3	35.7	33	.45	Poor to fair
Urea, 1 percent	35.3	34.0	38	.55	Poor to fair

[a] Proportion of contents of container discarded as unfit for feeding. [b] Calculated as lactic acid. [c] Based on observation of appearance, odor, and flavor.

The small containers were opened and the silage examined on September 3, sixty days after filling.

The silage made from unwilted oat forage was in most respects equal to that made from the wilted crop except in the untreated, or check, silos. The silage from the wilted and untreated crop had better color, odor, and taste than that from the untreated and unwilted crop and less of it was spoiled.

The addition of molasses seemed to improve the odor and taste of the silage and reduced the spoilage but had little effect on color. The acid content of the molasses-treated silages in every case was high, giving further evidence of the effectiveness of molasses as a preservative.

Urea as a preservative did not produce a high-quality silage but had a pronounced effect on color. The acid content of the silage was very low, presumably because the urea liberated ammonia which neutralized the acid. Since the acid content was low, the flavor was flat; and in the silage to which the larger amounts of urea were applied, the odor of ammonia was present. Altho the 1- and 1.5-percent urea treatments gave the silage good color and preserved it well, these amounts appear

too large to produce palatable silage. A silo of sorgo silage treated with 2.5 percent of urea was well preserved at the end of a year. The silage contained no acid and had a strong odor of ammonia. The addition of urea appears to inhibit the growth of molds and some of the other microorganisms that normally cause silage to spoil.

Sodium sulfate at .3- and .6-percent levels and ammonium carbonate at .3- and .75-percent levels appeared to have a slightly favorable effect, but the preservative action was not great enough to warrant recommending the use of these materials at the rates employed in these trials.

Recommendations. Ensiling oats when the grain is at the stiff-dough stage or the dry-matter content has reached 30 to 35 percent is recommended. Harvesting oats at an earlier stage is undesirable; but if necessary to harvest earlier, the forage should be wilted before it is ensiled or some dry feed, such as ground corn, should be added to bring the dry-matter content to the needed level.

Sorghum Silage

The value of sorghums for silage has been examined in four years' trials, during which studies have been made of: (1) several widely differing varieties; (2) the best time for planting and for harvesting as silage; (3) yields of sorghum varieties compared with those of corn and other crops; (4) effectiveness of preservatives and of combining sorghums with other crops in the making of silage; and (5) the feeding value of sorghum silage.

Better yields and better-quality silage was usually obtained when the sorghums were allowed to reach an advanced stage of development — 27 to 30 percent dry matter. This stage, however, required a growing period of 121 to 130 days after planting, while an adapted corn hybrid needed only 111 to 120 days to reach the same dry-matter level. Further details of these trials are reserved for later publication.

Recommendations. Sorghum varieties were found to vary widely in the number of days they require to reach maturity. It is therefore necessary to choose a variety which matures early in the area where it is to be grown. The dry-basis yields of late-maturing sorghums may be greater than those of adapted corn hybrids, but these sorghum varieties usually produce sour, soggy silage.

The quality of the silage made from sorghums can be improved by combining green soybean forage or silage corn with the sorghums. Yields and quality of silage can be improved in some seasons by planting adapted sorghums and soybeans together.

Winter Rye Silage

Growing winter rye helps to reduce erosion during the winter and early spring and makes it possible to get two crops a year from one field. In central Illinois winter rye seeded just after corn has been harvested for the silo will produce a large amount of forage the next spring. The crop may be used for pasture or silage, may be removed in April or May, and may then be followed by another crop such as corn, beans, or supplementary annual pasture.

Yields. At Urbana, winter rye grown for pasture has yielded 2,000 to 4,000 pounds of dry matter an acre. Assuming that silage contains 25 percent dry matter, these yields would be the equivalent to 4 to 8 tons of silage per acre.

Experiments with winter-rye silage. Rye harvested before it had headed, and ensiled without wilting or long enough after wilting to bring the dry-matter content to not more than 25.6 percent, made silage of poor quality (Table 13). Adding molasses at the rate of 2 percent increased the acidity slightly, but the product was still poor.

Table 13. — WINTER RYE SILAGE: Quality of Product as Related to Development of Crop at Harvest and Treatment When Ensiled

Treatment of crop	Preservatives used	Dry-matter content		Acidity[a]	Quality[b]
		Crop as ensiled	Silage as removed		
Before heading; harvested April 29-30; silos opened June 29					
		perct.	*perct.*	*perct.*	
Ensiled without wilting	No preservative	20.7	16.3	.88	Poor
	Cane molasses, 2 percent	20.7	17.1	.92	Poor
Wilted 1.5 hours	No preservative	25.6	19.3	.77	Poor
	Cane molasses, 2 percent	25.6	20.3	1.17	Poor
Wilted 6 hours	No preservative	33.3	22.9	1.66	Good
	Cane molasses, 2 percent	33.3	23.6	1.57	Good
Headed out; harvested May 7-8; silos opened July 7					
Ensiled without wilting	No preservative	19.6	21.4	1.48	Good
	Cane molasses, 2 percent	19.6	21.5	1.71	Good
Wilted 3 hours	No preservative	30.0	28.6	1.48	Good
	Cane molasses, 2 percent	30.0	28.3	1.71	Good
Wilted 4 hours	No preservative	30.1	33.4	1.11	Good
	Cane molasses, 2 percent	30.1	30.2	1.24	Good
Late bloom; harvested May 21; silos opened July 21					
Ensiled without wilting	No preservative	33.3	28.8	1.26	Poor
	Cane molasses, 2 percent	33.3	29.7	1.05	Poor

[a] Calculated as lactic acid. [b] Based on observation of appearance, odor, and flavor.

Wilting the crop in the field for six hours, or until the dry-matter content reached 33.3 percent produced silage of good grade. Adding molasses to the crop wilted six hours had little apparent value.

A crop harvested shortly after it had headed out made more satisfactory silage than that harvested at an earlier stage of development. When the crop was cured in the field for three or four hours, it made satisfactory silage. Adding molasses improved the silage only slightly. Rye ensiled on May 21, or more than two weeks after it had headed out, made silage that was musty thruout, had no distinct acid odor, and had a strawy consistency.

Recommendations. Getting a suitable dry-matter content is of first importance in making rye silage that will keep well. Before it heads out, the crop may contain only 16 to 20 percent of dry matter; and unless it is wilted in the field or some dry material such as ground corn is added, there will be much seepage of juices and the silage will be soggy and ill-smelling. After the crop heads out, the dry-matter content may increase so rapidly, especially if the weather is hot, that the plants may become too dry. Making good-quality silage from winter rye is therefore difficult.

SUMMARY AND CONCLUSIONS

Many considerations may influence the choice of a crop to be used for silage, but yield, the best time at which to harvest, and the most satisfactory means of ensiling are the most important ones. These considerations were therefore given special attention in silage-making experiments with alfalfa, soybeans, bromegrass, broomcorn, oats, rye, sorghum, and Sudan grass.

Under central Illinois conditions the high yields of *corn* and the *sorghums* make them outstanding silage crops. Some sorghum varieties, in tons of dry forage, may outyield adapted corn hybrids. After the brush is removed, *broomcorn* forage may equal corn forage in weight, altho the characteristics and yields of the various broomcorn varieties vary widely. First-cutting *alfalfa* and *soybeans* usually yield one-half to two-thirds as much dry feed as good corn hybrids. *Sudan grass* is a fairly high-yielding silage crop, the yields sometimes closely approaching those of hybrid corn. In these trials the silage crops of lowest yields were the *cereal-grain* forages such as oats and winter rye.

As silage crops, the characteristics of the crops studied differed; some differed from others in but one characteristic, some differed in more. No one rule can serve as a guide to the best harvest stage or

to the best kind and the proper amount of preservative to use. Because of all these differences, recommendations concerning harvesting and ensiling are included in the discussion of the experiments conducted with each crop.

Making good-quality silage from these crops proved more difficult than making good corn silage. If, therefore, satisfactory silage is to be made from grass and legume crops, the specific recommendations for each crop must be carefully followed.

Substances which it was found easy to add to the silage as it was ensiled and which proved effective in increasing palatability and improving keeping-quality of the various silages were: cane (blackstrap) molasses, corn molasses, and ground cereal grains. Materials which proved either ineffective or of little value as silage preservatives were: ammonium carbonate, ground corncobs, lactic acid culture, sodium sulfate, and urea.

The scope of silage-making can be greatly broadened by the use of a number of grass and legume crops in place of, or in addition to, corn.

6050—11-48—38918