An abundant supply of good quality roughage—pasture, hay and silage—produced at low cost, is one of the most important factors in profitable dairying. In Missouri we have developed a very productive, economical pasture system which places good pasture, almost the year round, within the reach of every farmer. The value of good quality, leafy green hay and methods of producing, curing, and handling it are well known. The methods of preserving corn,
sorghums and similar crops in the silo are also well known and little difficulty is experienced in obtaining good silage from these crops. The preservation of cereal grains and grasses and especially leguminous roughages has presented a new set of problems. The increasing use of leguminous forage crops, however, has stimulated studies relating to methods of preserving these crops in the silo. Several practical methods for the successful preservation of these crops have been perfected and are in wide use by dairymen and livestock raisers in general.

Advantages of Legumes, Grasses and Cereal Crops for Silage

1. Legume or grass silage may be made in periods unfavorable for the field curing of hay. This is especially applicable to the first cuttings of alfalfa and sweet clover. Other legumes, grasses and cereals may likewise be converted into silage.

2. A greater proportion of nutrients is conserved by ensiling the crop, and losses due to rains, sun bleaching, shattering of leaves, etc., are materially reduced.

3. An early season crop stored in the silo may be fed out as “summer silage,” thus supplementing short pastures and preventing the usual summer decline in milk production. The silo may then be refilled for fall and winter use.

4. Ensiling often proves practical in handling a damaged or weedy crop of legume hay or cereal grains. Most weed seeds are destroyed by the fermentation processes which occur in the silo.

5. The carotene content (responsible for the yellow color of milk fat) of the green crops is preserved more efficiently in the silo than in field curing. This is of considerable importance in winter feeding as dry roughages of low quality are often low in this factor.

6. Silage reduces storage costs. A cubic foot of grass silage weighs 8 to 9 times as much as a cubic foot of loose hay and contains about three times as much food value.

7. Silage from legumes, grasses, and cereals fits into a soil conservation program and lessens the necessity of growing soil depleting crops for silage purposes.

8. Silage is good “drought insurance” and is a valuable feed to be held in reserve for times of feed scarcity.

Crops for “Grass” Silage Purposes

Any crop that can be utilized as dry hay or roughage can be made into silage. The crops most commonly used for “grass” silage in the Middle West are:
Mixtures of legumes, grasses, or cereals may be used. Silos may be filled partly with one crop and completed with another if more convenient and the necessary precautions are taken.

The yield of silage obtained from legumes, grasses, and cereals varies greatly. Legume crops such as alfalfa or soybeans, yielding 1 to 2 tons of cured hay per acre will furnish approximately 4 to 8 tons of silage. Sweet clover usually yields somewhat more, often producing 6 to 10 tons of green material per acre.

Experience with wheat, barley, and rye, capable of yielding 18 to 20 bushels per acre, indicates that about 5 to 10 tons of silage per acre may be expected from such a crop. The grasses, timothy, etc. will usually yield from 3 to 6 tons and even greater amounts of silage per acre.

As a general rule, since most silages contain about 25 per cent dry matter and well cured hays about 90 per cent, the yield of silage will ordinarily approximate three to four times the tonnage of the cured crop.

**Time to Cut—Stage of Maturity**

Legumes and grasses should be harvested for silage purposes at the same stage of growth as they would normally be cut for the best quality hay. Young plants are most palatable, highest in protein and minerals, contain less fiber, and are highest in digestibility at the bloom stage or before. While the chief object is to obtain the greatest amount of nutrients per acre, there is often a tendency to cut legumes, grasses, and cereals too late for the most nutritious silage.

As a rule, alfalfa should be cut when the new shoots below the top growth are on the average about 2 to 3 inches long. Sweet clover should be cut before it is big enough to be very woody. Another rule is to cut both alfalfa and sweet clover when the field is about one-fourth to one-half in bloom. Red clover and alsike should be cut not later than full bloom. Soybeans should be cut when the pods are formed and one-third to two-thirds filled.
Timothy and grasses in general should be cut not later than full bloom. Prairie grasses should be cut before the plants begin to turn brown from dry weather or maturity.

Cereals should be cut as soon as headed out, or when in the milk stage, but no later, for best results.

**Harvesting and Ensiling**

The best method for harvesting will depend upon the crops and machinery available. A mower and side-delivery rake are commonly used for legume and non-legume hays. When available, special machinery for cutting and loading directly into the wagon or truck is very satisfactory. A grain binder is commonly used when cereal grains are to be put into the silo and has been used with good results in handling barley and wheat used for silage at this Station.

The ordinary silage cutter may be used advantageously for cereal crops. Where loose green hays are handled, however, a cutter especially designed with rollers and conveyor is most satisfactory. Such choppers are also adaptable for use with crops such as corn and sorgo and are carried in stock by farm machinery companies.

For legumes and grasses, some increase in operating speed of the cutter may be necessary, particularly for high silos, in order to prevent clogging of the blower pipe.

Loading green barley bundles for silage making.
Some General Considerations in Silage Making Methods

In filling a silo it must be kept in mind that packing so as to exclude air is very essential. Air pockets in the silo result in mouldy and dark colored silage, lowered in feeding value.

The walls of the silo must be smooth and tight. The ensiled material must be moist enough to pack readily. Even distribution of the ensiled material during the filling process is very important.

More than 20 years ago, Eckles of the Missouri Station found that good silage could be made from legume or non-legume hays and cereal crops by allowing them to dry in the field until the moisture content, normally about 65 to 85 per cent, was reduced to approximately 60 to 65 per cent, so that the dry matter content of the ensiled material would approximate 35 to 40 per cent. It is equally important that there be at least 60 to 65 per cent moisture present and if there is less than this amount water must be added. Any material variation in the dry matter content usually results in poor silage. Since under farm conditions it is difficult to determine the amount of moisture and so control the dry matter content of silage, better methods have been sought for preserving these green crops, especially the legumes. Chief among the reasons why difficulty is experienced in the ensiling of legumes is the low sugar and high protein content, which prevents desirable fermentation. Reed and Fitch of the Kansas Station first suggested the use of molasses in the preparation of alfalfa silage. Later studies have proven the value of molasses, and "molasses" silage is now widely used. Virtanen in Finland first suggested the addition of 2/N hydrochloric acid and sulphuric acid in 1925. Experimental work in recent years has also shown that phosphoric and certain other acids or combinations can be used successfully.

Molasses Silage

Molasses silage is prepared in the usual way except that molasses is added. The molasses may or may not be diluted with water, and may be added just as the green material enters the cutter, or introduced into the blower. A very satisfactory method is to mount the barrel on an elevated platform above the cutter and run a pipe from the barrel to the cutter; or the molasses may be forced from the drum under pressure by pumping air into the drum. From 40 to 80 pounds of blackstrap or cane molasses should be added per ton of silage. However, satisfactory results have been secured by adding as little as 20 pounds. As a rule, the approximate amounts recommended are as follows:

- (a) cereal grasses—40 to 50 lbs. (3½ to 4 gal.)
- (b) mixed grasses and legumes—60 to 70 lbs. (5-6 gal.)
- (c) legumes—70 to 80 lbs. (6-7 gal.)
A simple means of measuring the rate of the addition of molasses is to (1) time a load of hay as it goes through the cutter; (2) fill a quart jar or milk bottle from the stream of molasses and check the time necessary to fill it; (3) multiply the number of minutes required to run a ton through the cutter by 180 and divide by the number of seconds required to fill the bottle. This gives the number of pounds of molasses or molasses-water mixture being added per ton. By using a little care the molasses stream may be adjusted so that it runs at the correct speed to add the amount of molasses desired. A gallon of molasses weighs about 12 pounds.

Advantages of Molasses Silage.—(1) The odor and palatability of the silage is enhanced as compared to normal untreated silage.

(2) Somewhat better preservation of proteins, carotene, and other nutrients is obtained, as compared to normal silage.

(3) Milk produced on molasses silage contains about as much Vitamin A and carotene as milk produced on silage preserved by any other method such as the A. I. V. or phosphoric acid processes, even though the analyses of the silages themselves may show that they contain only about two-thirds as much of these factors.

Adding molasses to material in the cutter box by means of an elevated drum fitted with regulating valves.
(4) Addition of molasses may slightly increase the amount of food nutrients over that in normal silage.
(5) The amount of molasses added need not be exact.
(6) This method may be used advantageously when wet weather endangers the hay crop. It can be put in the silo with little loss due to leaching, discoloring, or loss of leaves.
(7) There are no known disadvantages or precautions which must be observed in feeding it.
(8) The cost of the molasses approximates 25c to 75c per ton of silage, varying with the amount used and the price of molasses.

Under average farm conditions the molasses method is probably the most satisfactory for general use of the several methods described in this publication, although the quality of silage obtained by all methods will ordinarily be about equal.

The A. I. V. Method

The A. I. V. method of ensiling green crops is named for Dr. Arthur I. Virtanen, Director of the Valio Research Laboratory, Helsinki, Finland. The essential feature of the A. I. V. method is the addition of sufficient amounts of acid to prevent fermentation, appreciable breakdown of the proteins, carotene, and nutrients. The acids used are ordinarily 2/N sulphuric and hydrochloric in equal amounts, although 1/4 sulphuric and 3/4 hydrochloric is sometimes used.

Amount of Acid, Cost, Precautions, and Methods of Use.—Plants rich in protein require more acid to raise the hydrogen ion concentration of the ensiled material to a pH of 3 to 4 than crops such as corn or the cereals or grasses which are higher in sugars and readily form lactic acid. Below a pH of 3 the silage is too sour and unpalatable and above a pH of 4 the preservation is not sufficiently complete. Therefore, it is necessary to determine accurately the amount of acid to be added. As a general rule, non-legume crops require about 10 gal. of 2/N acid, and legumes 20 to 25 gal. per ton of green material. The cost of the acid required to preserve a ton of green material usually varies within the approximate limits of 60 to 90 cents, depending upon the quantity required and the availability of the acid. The acid is very corrosive to machinery, clothing, and the skin of those using it, and therefore special precautions must be taken in handling it. It should be kept in a wooden tank and a special acid-resistant pump, usually of bronze, and rubber hose is required. The acid should not be introduced into the cutter or blower, but sprayed directly over the surface of the silage. Because of the damage to paper lining, which results in excessive spoilage,
the acid method is not ordinarily satisfactory for use in most temporary silos, and special acid-proof treatment must be used in concrete, metal, and certain other types of permanent silos. The A. I. V. process is patented in this country and royalty rights of $1.00 per cow per year are charged. Chapman Dairies, Lee’s Summit, Missouri, is the holder of the U. S. patent rights on this process.

**Advantages of the A. I. V. Process.**—(1) Legume crops may be ensiled which can be harvested independent of weather conditions with very little loss due to leaching, discoloring, drying or shattering of the leaves.

(2) Nutrients are preserved very efficiently with little loss of protein and vitamins.

(3) The milk produced by cows fed A. I. V. silage is richer in color and vitamins, especially in the winter months, as compared with milk produced on normal winter rations.

(4) A. I. V. silage has no significant effect on milk production but the nutritive value of the milk is increased as compared with that of milk from cows fed normal silage. In this respect it gives results closely approximating but not quite equaling that of green grass or good pasture.

(5) The cows show no noticeable ill-effects physiologically from consuming fairly large quantities of the silage. However, experimental studies indicate the desirability of feeding a reasonable amount of hay when A. I. V. silage is fed, or 3 to 4 ounces of ground limestone daily to neutralize a portion of the acid when A. I. V. silage is the principal or sole roughage.

**Phosphoric Acid Silage**

Commercial phosphoric acid (about 68-75%) is now being used in the preservation of silage crops. The acid is diluted by adding one part of acid, by volume, to five parts of water—*never add water to acid*. The diluted acid is applied directly over the feeding table as close to the knives as feasible. It may also be applied into the lower part of the blower housing.

In applying the phosphoric acid, home-made equipment consisting of a barrel, painted inside with asphaltum paint and equipped with two valves for regulating the flow of the acid-water mixture may be used. Enough acid-water mixture may be poured into the barrel for each load and the valve opened when cutting starts and closed just before it stops. Or, the amount required per load may be determined as described under the molasses method, and the valve adjusted to deliver this amount from the elevated barrel in the course of time required to run a load of the green material through the
cutter. Two valves are used on the outlet from the barrel, one valve to regulate the flow, and the other to open and close the line.

Less acid is required to preserve non-legume material or mixed grasses than legumes. The usual recommendations are 8 to 9 pounds (2 2/5 quarts) per ton for cereals and grasses, and 14 to 18 pounds for legumes. Ordinarily, approximately 16 pounds (11/4 gal.) of acid to the ton of legumes are recommended.

The cost of the acid varies but it may usually be purchased in 15 or 30 gallon drums at approximately 7 to 7 1/2 cents per pound, which means that the cost need not exceed about $1.00 per ton of silage. It should be noted that both A. I. V. and phosphoric acid silages are cold silages, freezing earlier in the winter and remaining frozen longer in the spring than normal corn or molasses silage. Likewise, in each case it is desirable to feed a reasonable amount of hay or 3 to 4 ounces of finely ground limestone daily when either silage makes up the principal or sole roughage.

Advantages of Phosphoric Acid Silage.—Advantages claimed for this method are (1) that it produces favorable conditions for the preservation of the ensiled crop with little loss of green color or nutrients.

(2) The silage is less corrosive than A. I. V. silage (sulphuric and hydrochloric acids).

(3) The quantity of available phosphorus in the ration is increased.

(4) The resulting manure has a higher phosphatic fertilizer value.

Feeding Legume, Grass, or Cereal Silage

"Grass" silage may be used to replace either corn or sorgo silage, or hay, or both. Silage as a general rule is high in moisture and irrespective of the crop from which it is made, must be considered as a succulent feed and therefore should be properly supplemented with grain to give best results for milk production.

Silage made from legumes, grasses, or early cut cereals contains more protein than silage made from corn or sorgo. Where "grass" silage is fed along with legume hay, a grain ration containing about 14 to 16 per cent crude or 10 to 12 per cent digestible crude protein should be fed. Where the roughage fed is chiefly silage (60 to 90 pounds per day) the grain mixture should contain 16 to 18 per cent crude or 12 to 14 per cent digestible crude protein.

When feeding silage it is well to keep in mind that as a rule three pounds of corn, sorgo, legume, grass, or cereal silage is equal to one pound of dry legume hay for feeding purposes. Cows in milk, when fed silage, should ordinarily receive a roughage ration of 3
pounds silage and 1 to 1½ pounds of hay or other dry roughage per 100 pounds body weight. This will usually mean feeding 30 to 40 pounds of silage and 10 to 15 pounds of hay. In special instances where it is desirable to feed silage as the only roughage, up to 60 to 90 pounds daily may be fed, but this practice requires grain feeding at a heavier than normal rate in order to insure the cows receiving sufficient energy for maintenance of milk production at a high level.