The Trench Silo in Arizona

Arizona Agricultural Experiment Station

UNIVERSITY OF ARIZONA

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SUMMARY

Pertinent facts to remember about the trench silo in Arizona.

1. The trench silo provides low-cost storage for succulent feeds.
2. It is adaptable to most Arizona conditions.
3. The silo should be constructed with sloping walls. Silage packs tighter to these walls. The slope should be one foot for each 8 feet in depth.
4. The maximum slope for the driveway should be 1:4.
5. The depth of a new silo should be approximately equal to the width with a maximum of 20 feet in depth.
6. The standard silage feeding program is 35 pounds per cow per day. One cubic foot of silage averages about 35 pounds.
7. The size of the cross-section of a trench silo should be determined by the size of the herd. The length should be governed by the length of the feeding period.
8. Finely cut forage thoroughly packed will have a minimum of spoilage.
9. A wheel tractor is recommended over other types for packing silage in the trench.
10. Silos should be sealed by additional wetting and packing for three to five days after filling. At the end of that time, do not allow the seal to be broken until the silage is removed.
11. Self-feeding from an above-ground, horizontal silo saves labor.

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The Trench Silo in Arizona

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Preservation of green feed has some new techniques as the result of our modern power machinery. In principle and in use, however, the preservation and feeding of silage is centuries old. Historians tell us that the ancient Greeks and Romans preserved grain and green feed in underground pits.

In Arizona, trench silos have been the most common type of silo for the past three decades. Very few of other types have been constructed where soil or other conditions are favorable to the trench silo.

Silage is made principally from alfalfa, grasses, sorghums, corn, and small grains. The materials have to a small extent been ensiled unchopped, but chopped forage is much preferable both for better preservation and for ease in filling and emptying the silos.

This bulletin deals with the harvesting and handling of silage with respect to trench silos; and with the construction, maintenance, and use of these silos.

Advantages of the Trench Silo

1. Low cost of construction as compared with other types of silos.
2. Modern mechanical equipment may be utilized in filling and removing silage more quickly.
3. Depreciation and repair costs are relatively small.
4. Less expensive machinery can be used to fill the trench as compared with the vertical silo.
5. Less labor is required to remove silage from the trench silo as compared with other types.
6. Compacting the forage in the trench can be done with trucks and tractors rather than tramping by men.
7. Feed may be removed from one end while filling the other end.

Disadvantages of the Trench Silo

1. The trench silo is not so permanent as other types of silos unless the walls are lined.
2. Greater spoilage occurs in the trench per unit of storage due to larger exposed surface.
3. Additional spoilage may be caused by gophers burrowing through the walls and admitting air unless the walls are lined.
4. The trench silo detracts from the appearance of the farmstead.

Adaptability and Durability

Trench silos have proven satisfactory in soils of Arizona from sandy loam to heavy clay. Unlined trenches are not adapted to the very sandy soils. Soils containing cobblestones are undersirable because they make it difficult to keep the walls smooth.

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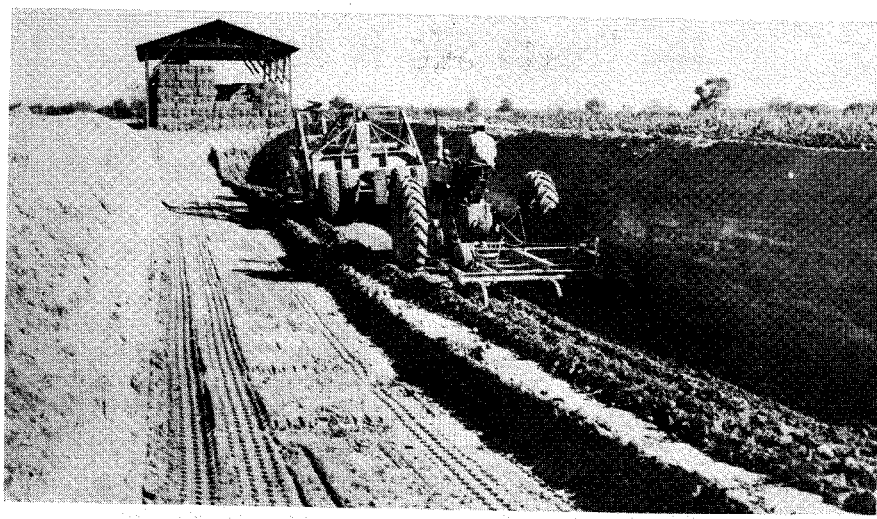


A minimum amount of hand labor is required in constructing the trench silo.

The walls of trench silos in so-called medium and heavy clay soils will stand for several years in good condition. One large silo in heavy clay soil was used for 10 consecutive years with very little change in the walls. Another large silo in a sandy loam soil has been in use for 20 years. A small amount of labor was needed each year to smooth the walls of these unlined silos before refilling.

Location

The silo should be constructed in a well-drained site free from seepage of ground water. There have been instances where water has been several inches deep in silos in heavy clay soils for extended periods without apparent damage to the silage. Water flowing through the silage would likely admit air, causing spoilage and also leach valuable nutrients.

The silo should be located where vehicles used in filling and unloading can operate conveniently. The site selected should be convenient to the place of feeding but need not be particularly close to the feeding area. A well-drained site is essential. Freedom from both seepage of ground water and surface water is of prime importance. A water supply piped to the vicinity of the silo is needed when filling the silo with partially dried material—and for sealing the silo.

The trench may be dug from level ground. This occasionally makes a silo difficult to drain after heavy rains. It may also be dug from the side of a hill in which case the floor level is sloped downward to the entrance. A third and less common method is that of building up the sides with earth from an outside source. This earth is packed and the inside walls are sloped and smoothed. This type is the least desirable from the standpoint of farmstead beauty.

Trench silo walls lined with gunnite will last for many years.

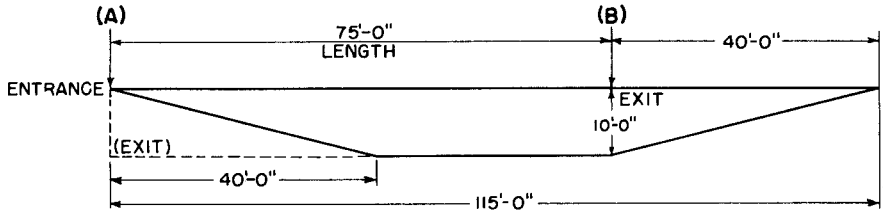
Shape of the Silo

Sloping Walls. Smooth, sloping walls are highly recommended to prevent caving and to allow more complete packing. Tractors can compact the forage very closely to a sloping wall. The silage also settles tightly against a sloping wall, thus keeping out air and reducing spoilage. Perpendicular walls permit the silage to settle away from the walls, admitting air and thus promoting spoilage.

In most "heavy" soils (high clay content) the slope of the walls should be 1 foot for each 8 feet in depth. A silo 8 feet deep would be 2 feet wider at the top than at the bottom. In sandy soils where the tendency to cave is greater, the walls should have a slope of one to four. For example, a trench 8 feet deep would be 4 feet wider at the top than at the bottom.

Perpendicular Walls. In recent years, most trench silos have been constructed with heavy, earth-moving equipment. Bulldozers and carry-alls are normally used. It is difficult to dig a trench silo with sloping walls using this equipment. Therefore, many silos in the state have perpendicular walls when newly dug. The annual shaping of the walls gradually produces a slope inward from top to bottom. The silo with perpendicular walls preserves the silage well when special attention is given to packing the forage along the edges of the trench. Packing by use of a wheel tractor once a day should be continued three to five days after the silo has been filled. After five days, a mold seal will have formed which prevents further spoilage. This seal should not be disturbed by further packing.

Driveways. Present-day silos are usually constructed with an incline



Measurements for determining size of trench silo.

to ground level at each end. Trucks and wagons are driven into the silos, unloaded and driven out the opposite end. The slope at either end should be 4 to 5 feet for each 1 foot rise. When the silo is not completely filled, at one time, it is possible to feed from one end while adding freshly cut forage to the other end. The chief disadvantage of the double driveway is increased surface area exposed for spoilage.

Use of Removed Soil. The soil removed from the trench can be piled along the sides of the trench to increase the capacity of the silo —as much as 25 per cent. Many dairymen and cattle feeders prefer to have part or all of the soil placed in mounds within the corrals. These mounds provide better drainage and afford a dry area for the cattle during wet weather. This also is a readily available source of fill dirt for grading the low spots which develop from normal use.

Ratio of Width to Depth. The depth of a new silo should be approximately equal to the width. A trench 12 feet wide should be 10 to 12 feet deep. Each year, before the new crop is placed in the silo, the sides of the unlined trench should be smoothed. It thus gradually becomes slightly wider with respect to the depth. There will be too much spoilage in a wide, shallow trench. However, a trench less than 12 feet wide is too narrow for modern machinery. Unless a trench is extremely long, a depth of 20 feet should be the maximum. Driveways at least 160 feet long would be needed to drive equipment in and out of a silo approximately 20 feet deep.

Length. The length of a silo, after the width and depth have been established, will be determined by the silage feeding period or the amount of feed to be stored. In some instances the location may determine the dimensions of the silo.

Size of Silo

How can you determine the right size of silo for your operation?

Herd size, and amount of sliage to be fed daily, should determine the cross-section area (width x depth) of the silo. Length of feeding period or amount of silage to be stored will determine the length. The entire feeding surface (cross-section) should be removed every three to five days during

cool weather and every two to three days during hot weather.

A suitable method for calculating the cross-section for your silo is: (1) take the number which is double the number of cows in the herd (2) use this figure as the cross-sectional area of your silo—if you plan a standard silage feeding program using about 35 pounds per cow per day.

For example, if you have a 60-cow herd, multiply 60 by 2. Thus, 120 square feet (60 time 2) would be the desired cross-sectional area of the silo. A trench 10 feet deep and 12 feet wide would give the desired size. When you intend to feed less silage, or when the silo is to be used exclusively for alfalfa silage, multiply the number of cows by 1½.

Cows will eat an average of 35 pounds of silage each day under a standard silage feeding program. Settled silage weighs approximately 35 pounds per cubic foot. Thus each cow will eat about 1 cubic foot of silage per day. The daily consumption of the entire 60-cow herd would be equal to a slice of silage 6 inches (½ ft.) thick, 12 feet wide and 10 feet deep (12 x 10 x ½ equals 60 cu. ft.).

The length of the trench can now be calculated based on the use of ½ foot of silage per day. The length in feet can be determined by dividing the length of the feeding period in days by two. Example: When silage is to be fed from November first through March, (150 days) divide 150 by 2 to obtain the length in feet. In this example, the length would be 75 feet. (Note the diagram.) Table 1 may also be helpful for this calculation.

Determining Width, Depth, and Length of a Trench Silo

You must know the width, depth, and length to calculate the capacity of a silo. Determine the width by adding the width at the bottom to the width at the top and dividing by two. Use only the bottom measurement when the walls are perpendicular.

Measure the depth from ground level to the bottom of the trench near the middle of one silo wall. Then measure the length according to the accompanying diagram from the entrance (A) of the trench at ground level to the beginning of the exit (B). Inspection of the diagram shows that placing the part labelled "exit" upside down under "entrance" would result in a rectangle. We refer to the previous example of a trench 10 feet deep, 12 feet wide, and 75 feet long. The distance of 75 feet extends from (A) to (B) in the above diagram. The over-all length of the trench would be 75 feet plus 40 feet or 115 feet where the driveways had the maximum slope of 4 to 1.

Determining the Capacity of a Trench Silo

Table 1 presents the estimated tonnage per running foot for trench silos of various widths and depths. The capacity is determined by multiplying the tonnage per foot (as shown in the table) by the length of the silo.

Example: The 10 x 12 foot trench silo will contain 2.1 tons per linear foot, according to the above table. The trench is 75 feet long and contains 2.1 tons per foot or a total of approximately 157 tons of silage (75 x 2.1).

The weights used in estimating the capacities of silos as given in Table 1 were obtained in the Middle West for silage made from corn under average conditions of moisture and grain content. Limited data for sweet and grain sorghum silage show no wide variations in weight as compared with corn silage. These data are based on settled silage and will not apply to the weight of unsettled silage.

Approximately 15 days are required for complete settling of the silage material. The degree of settling will vary with the manner of filling the silo. When each load is spread and packed carefully in the silo, settling will be kept to a minimum. This results in more feed storage per cubic foot of space.

Factors Influencing the Weight of Settled Silage

The chief factors affecting the weight are: (a) the moisture content of the silage, (b) the proportion of grain to stover, (c) the depth of the silage, (d) the width of the silo, (e) the crop used for silage, (f) the length of cut forage, and (g) extent of packing during the filling operation.

Table 1 is to be used for settled silage when percentages of moisture and grain are average. The following modifications are suggested in the Missouri bulletin when extreme conditions are encountered:

Table 1. Capacity in Tons Per Foot of Length of Settled Silage

Depth of silage	Average weight of silage to the cubic foot to this depth[1]	AVERAGE WIDTH OF SILAGE IN FEET[2]							
		6	8	10	12	14	16	18	20
Feet	Pounds	Tons	Tons	Tons	Tons	Tons	Tons	Tons	Tons
6	33.7	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
7	34.1	0.7	1.0	1.2	1.4	1.7	1.9	2.1	2.4
8	34.4	0.8	1.1	1.4	1.7	1.9	2.2	2.5	2.8
9	34.7	0.9	1.2	1.6	1.9	2.2	2.5	2.8	3.1
10	35.0	1.0	1.4	1.8	2.1	2.5	2.8	3.2	3.5
11	35.3	1.2	1.6	1.9	2.3	2.7	3.1	3.5	3.9
12	35.6	1.3	1.7	2.1	2.5	3.0	3.4	3.8	4.3
13	35.9	1.4	1.9	2.3	2.8	3.3	3.7	4.2	4.7
14	36.2	1.5	2.0	2.5	3.0	3.5	4.1	4.6	5.1
15	36.4	1.6	2.2	2.7	3.3	3.8	4.4	4.9	5.5
16	36.7	1.8	2.3	2.9	3.5	4.1	4.7	5.3	5.9
17	36.9	1.9	2.5	3.1	3.8	4.4	5.0	5.6	6.3
18	37.1	2.0	2.7	3.3	4.0	4.7	5.3	6.0	6.7
19	37.3	2.1	2.8	3.5	4.3	5.0	5.7	6.4	7.1
20	37.5	2.3	3.0	3.8	4.5	5.3	6.0	6.8	7.5

[1]Average weight of silage taken from Bulletin 164, Missouri Experiment Station.
[2]Of course the narrower widths will not be used for silos in Arizona; but the values in such columns may help in calculating widths not in the table. For example: Combining the tonnage in the 6-foot width and that in the 20-foot width would give a reasonably close tonnage for a silo 26 feet wide.

The wheel tractor does an excellent job of packing the silage.

1. When the corn is put into the silo in a less mature condition than usual, in the milk stage or very early dough stage, add 10 to 15 per cent to the weights given in the table.
2. If the grain is unusually heavy in proportion to the stalk, add 5 to 10 per cent to the figures in the table.
3. If the forage ensiled is alfalfa, add 20 to 25 per cent.
4. If the corn is past the usual stage of maturity for ensiling and obviously contains less moisture, deduct 10 to 15 per cent.
5. If very little or no grain is present, deduct 10 per cent.

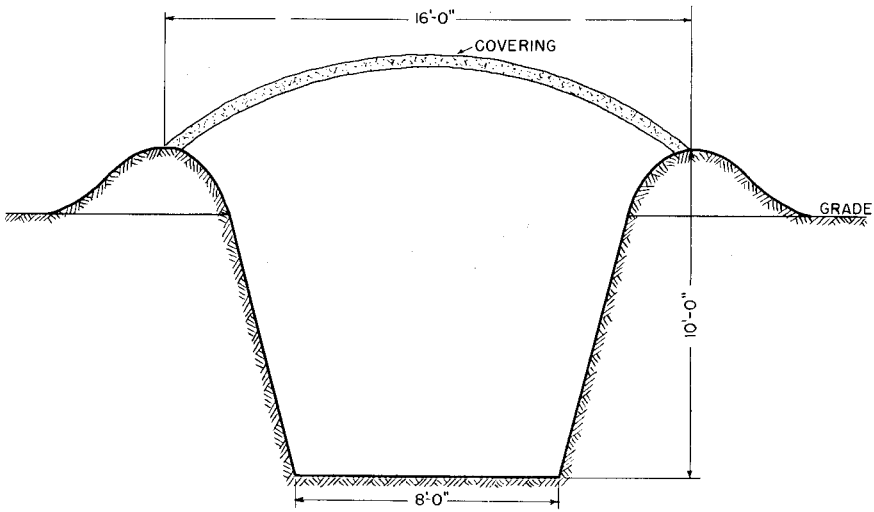
Cost of Construction

There is very little cash expense in constructing a trench silo if it is done with available farm labor and equipment. Two men with the necessary equipment should do the excavation for an 80-ton silo in two and one-half to three days. Results obtained from a Texas silo study in 1953 show construction costs to be approximately $90, $110, and $122 for 100-ton, 150-ton, and 200-ton unlined trench silos. The respective costs for concrete-lined silos were $760, $1110, and $1466.

Most trench silos in the major agricultural areas of this state are dug by earth-moving contractors. They use modern bulldozers and carry-alls. Custom rates are based on the number of cubic yards of soil removed.

Field Equipment

The forage harvester is well-suited for silage production in Arizona. Its attachments make it a versatile machine adapted for use with row crops such as hegari for



Cross section of trench silo at time filling is completed. Straw or spoiled silage make excellent material for sealing the silo.

cutting green feed or for use with windrowed forage. Self-propelled forage harvesters have been introduced into some areas recently. The harvester cuts, chops, and elevates the feed into a wagon or truck beside or behind the machine. The single row harvester will chop approximately 100 tons of silage material per day under usual operating conditions. This equipment should not only do satisfactory work, but also has simplicity of design, durability, large capacity, and low cost.

In this state, the 4- to 5-foot mower attachment is most commonly used in cutting forage for grass and alfalfa silage. This unit is interchangeable with the pick-up and row-crop attachments. This size has proven very satisfactory for the heavy yielding crops grown in the irrigated valleys of Arizona.

It is well to consider that medium to light crops when cut with the field chopper save very little labor over mowing and windrowing. Field chopper travel per ton is high and tonnage harvested per hour is low. When the crop is mowed and windrowed first, little more total tractor travel is required and chopper travel is but slightly more than half. This comparison is based on a mower cutting a 7-foot swath and a field chopper making a 4-foot cut.

Windrow attachments may be more troublesome where border irrigation is used. A windrow attachment used in light crops where two windrows are raked together and chopped requires slightly more tractor travel and approximately one-fourth as much field chopper travel as chopping directly with a 4-foot cut. High-moisture crops may be wilted and moisture reduced sufficiently when chopped from the windrow before ensiling. *Silage harvesting operations are more efficient when field chopper travel is reduced.*

Windrow Attachments—Two Types

Type 1. Long steel fingers are attached to the cutter bar of the mower which roll the forage into a

The forage harvester is used to harvest the silage.

windrow near the inside of the swath. This type has a tendency to bunch the forage.

Type 2. Short steel fingers on either end of the cutter bar roll the forage to the center of the swath. This type works best in long forage. In short forage, the swath is difficult to pick up. The side-delivery rake may be used to combine two small swaths into one to facilitate the picking-up operation.

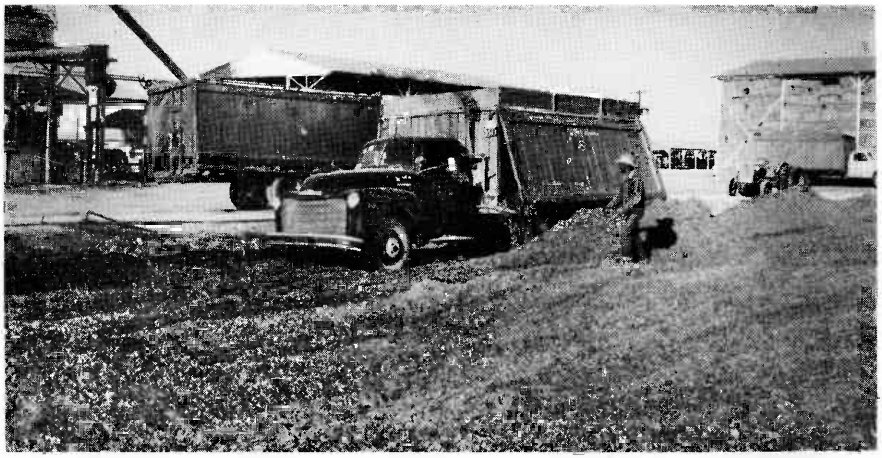
Filling the Trench Silo

The walls of the trench silo should be wet just previous to filling. This eliminates spoiled silage along the walls. The forage is usually ensiled as quickly as possible after cutting. When making grass or alfalfa silage from forage cut early in the spring, or from immature forage, wilting before ensiling is essential. Alternate loads of high- and low-moisture forage placed in the silo is also beneficial. The usual procedure is field chopping and unloading into the trench. However, small operators with limited equipment have ensiled long forage. Uncut forage is difficult to handle, to remove and to feed. It is more difficult to pack solidly to prevent spoilage.

Various types of trucks and wagons are used to haul the feed to the trench. Dumping or dragging the forage into the trench is easier and faster than distributing it through a blower or elevator placed at the side of the trench. Dumping or dragging makes the even distribution of preservatives very difficult.

Feed wagons that unload mechanically are ideal for conveying silage into the trench. Standard-type wagons may be rigged with a canvas or woven wire sling to form a false bottom. The sling is pulled from the wagon in the direction of the trench. Many operators use dump trucks and use these heavy trucks for packing the material as they drive through the silo.

When making grass or alfalfa silage, first put in two to three feet of slightly wilted or somewhat drier forage on the bottom of the trench. *Early in the spring, during*



Two methods of filling the trench silo.

cool weather this material should not be packed nor more material added until the initial layer has warmed up to 100°F. but not over 120°*F.* This procedure will help to prevent the development of rancid or high butyric acid silage in the bottom of the trench.

Pack the initial layer after the warming-up procedure; filling may then be continued rapidly with thorough packing from wall to wall. This "warming up" period is not necessary during the summer.

Continue to fill and pack until the forage is piled well above the top of the trench, with the center slightly higher than the edges. The packing should continue three to five days and more forage should be added if necessary. When ready to seal the forage at the center should be two feet or more above the top of the trench, with a well-rounded crown extending over the side walls. This prevents the entrance of air and water and reduces side spoilage.

A wheel type tractor equipped with a "dozer" blade or renovator attachment is the most satisfactory equipment for spreading and packing forage in the trench. This equipment helps spread the silage uniformly and to pack it as the tractor goes back and forth over the entire surface.

The silo should be filled on a slope comparable to the slope at the ends of the silo. This will permit the vehicles to drive over the filled portion and aid in packing. This procedure also lends itself well to intermittent additions of harvested forage. Often there is not enough forage at one time to completely fill the trench.

When filling is resumed, the full advantage of the heavily loaded wagons is utilized in packing the fresh-cut forage on the small layer of dried and partially spoiled feed. Opinions are divided as to how this spoilage should be handled. Numerous operators ignore this rather insignificant amount of discolored feed and spread fresh forage over it. A narrow band, dark in color and one to two inches thick will be evident when removing silage for feeding. The small amount of discolored silage had no apparent effect on the over-all consumption of the silage.

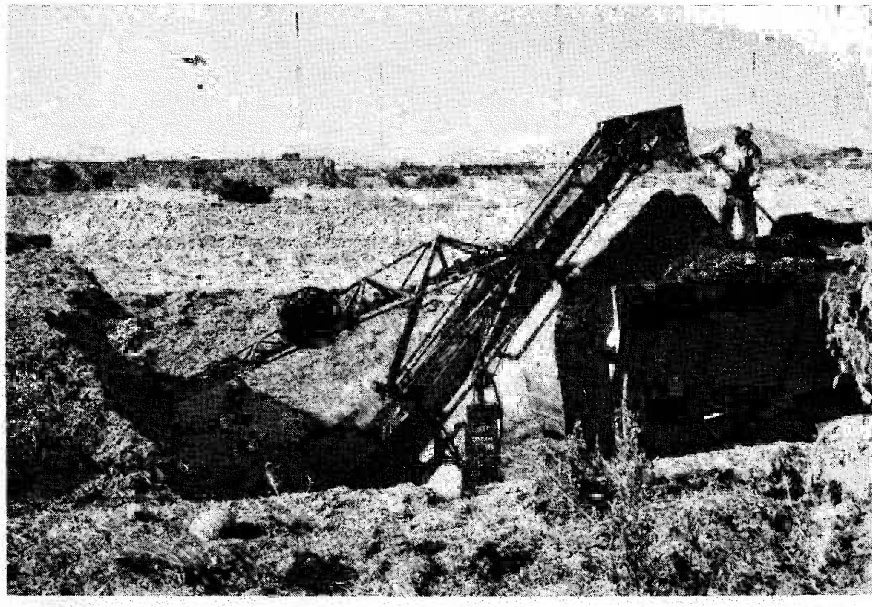
The top layer should consist of high-moisture forage to aid in sealing the trench. The addition of water to dry forage on the top layer facilitates sealing. If too much water is added, seepage losses will increase. Avoid this.

A good seal for the trench silo may be made by covering the forage with heavy, reinforced paper, sometimes weighted by soil. Alternatives include the use of three or more inches of sawdust, cotton gin waste, cottonseed hulls, or similar material wet down and packed thoroughly. Some operators feel that the labor, machinery, and material involved in making a seal is more costly than the amount of silage saved providing they do a good job of packing the top layer of silage material.

Removing Silage from the Trench

One of the chief objections to the use of a trench silo is the difficulty of removing the feed. The silage fork with manual labor has been replaced in large operations with mechanical loaders. Conveyors are also used to load the wagons or trucks. A strip of silage of the desired width may be cut. The loosened feed is then loaded with a tractor scoop.

Ingenuity may pay off. For example, one small operator has welded several ½ inch steel rods



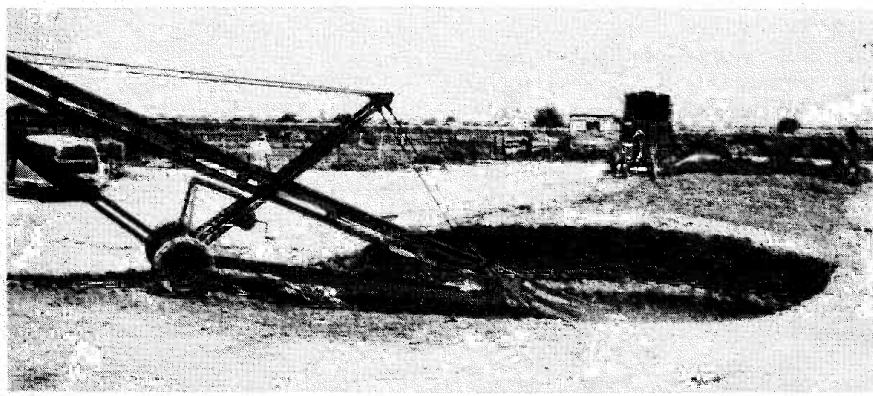
The silage is removed with a mechanical loader. Among the advantages of the mechanical loader is the elimination of many hours of labor in the very high temperature of a silo.

to the bottom of the hydraulic manure scoop. The rods project forward 16 to 18 inches, and are spaced 4 to 5 inches apart and are drawn to a blunt end. This equipment eliminates hand work.

Unchopped silage in small trenches must be cut loose with a sharp, broad ax.

Self-feeding Silos

The chief advantage of the self-feeding silo is the saving of labor in removing the feed. Construction costs and spoilage losses are greater in this type of silo. The maximum depth should be eight feet of settled silage.



Removing silage from one end of a trench silo while filling the other end.

COVER PICTURE
Trench silo with entrance at both ends. Excavation dirt was used to increase depth.

A BIT OF HISTORY

Trench silos have been with us in Arizona for a long time. The first one on record was constructed in 1910 by Mr. Ralph Murphy, near Glendale. A demonstration of the trench silo was made in 1922 by E. S. Turville, Pinal County Agricultural Agent on the farm of W. D. Ryder near Casa Grande. This was done to study the possibility of preserving forage in bundles. Hegari was harvested with a binder and placed in this silo. There was considerable spoilage between the bundles, but it was evident that this method of storing green feed had possibilities. More recent trials proved that finely cut silage was greatly superior to the long cut.

The first University of Arizona publication advocating the use of the trench silo in Arizona was written by R. N. Davis (senior author of this bulletin) in 1922. In 1932, he wrote Extension Circular 74, entitled, "The Trench Silo in Arizona."

ACKNOWLEDGMENTS: All pictures in this bulletin were taken by Robert Halvorson, of the Arizona Agricultural Extension Service.

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