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Packaging and Handling Silage in Bags

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SUMMARY

An attempt was made to find a satisfactory method of handling and storing silage in containers that hold between 1000 and 1500 pounds of silage. The containers tried were bags 4 ft. in diameter or 4 ft. by 4 ft. in cross section.

Bags of silage of this size can be handled with a farm tractor on pallets as long as the bag remains in an upright position.

No satisfactory method of storage was found. Difficulties encountered were:

1. The bags were difficult to fill and every method attempted ended with someone manually spreading the silage and tramping it in the bags.
2. Moisture movement in the bags caused the material in the bottom of the bag to have a high moisture content, while the material in the top of the bag was relatively dry.
3. All bags stored outdoors contained enough deteriorated forage (ensilage) unsuitable for livestock feeding that this method of storage could be called unsatisfactory. (It should be pointed out that no preservatives were used in these tests and that clear plastic bags were used.)
4. It was found difficult to fill a plastic bag with chopped forage and obtain a package that would stand in an upright position. Plastic bags filled with chopped corn would not retain their original shape.

Fiber and asphalt paper bags do retain their shape and therefore handle better than the plastic bags. However, the spoilage of the silage in these bags precludes their use for this purpose unless better ensiling conditions can be maintained.

Results were negative. This bulletin is written to: (1) present the methods used to fill and handle the bags; and (2) set forth the findings and the difficulties encountered for those who contemplate further research in this area.

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INTRODUCTION

The storage of silage in plastic containers has been attempted by several researchers. Bloomfield and Muhrer (1)* placed 100 pounds of silage in 6 mil. polyethylene tubing that was approximately 50 inches in circumference. They report that the silage was preserved in a satisfactory manner. Sprague (3) reports on two experiments with 100-pound bags of grass-legume forage. Twenty-four bags were used in each experiment in which various types of preservatives were used. All bags, including those with which no preservative was used, gave good preservation, with the exception of bags containing forage treated with ethylene gas.

Sprague (3) also filled 16 plastic silos with 100 pounds of silage. Eight contained sorghum and eight were filled with alfalfa. Again, storage was successful, with dry matter losses as low as 5 percent. Sprague also reports on five other silos ranging in size from 12- to 67-ton capacity. He allowed for seepage from the larger containers.

Briggs (2) used plastic film bags as silos in a study conducted at Minnesota. He reports a dry matter loss figure of 5 percent for 15 tons of alfalfa. For corn silage in 7- and 37-ton silos, the dry matter loss was 1 percent or less.

These reports are encouraging, and indicate that silage can be preserved in plastic film containers if the container can be kept sealed. Briggs (2) further states that in the case of high-moisture legumes, preservatives are required.

It should be noted that none of these research efforts was directed toward the minimizing of labor in filling the containers or toward mechanizing the handling of the silage in its container at feeding time. The objective of this research was to find a low-cost, all-weather, self-contained storage unit for silage that could be moved conveniently about the farmstead.

METHODS AND PRINCIPAL ACCOMPLISHMENTS

The various parts of the research will be presented in the chronological order in which they were carried out.

Experiment 1

In the first experiment a total of 45 plastic film bags, 4 feet by 4 feet in cross section, were filled to a depth of approximately 6 feet, some with chopped alfalfa and some with chopped corn silage. The filled bags were transported by means of pallets and a fork lift on the rear of a tractor. The bags were stored on the

*Numbers in parentheses refer to references listed at the end of the bulletin.

pallets in a fenced enclosure open to the weather, but designed to be rodent proof.

Chopped alfalfa was placed in 35 of the bags in June and July. The moisture content of the alfalfa varied from approximately 76 percent for direct cut material to 52 percent for material wilted in the field.

Two methods of filling the bags were used. The first 25 bags containing alfalfa were filled in the field. This system utilized a specially constructed two-wheel trailer that held a plywood form. The bag was suspended within the form and was filled directly from the chopper chute. When the bag was filled, the top edges of the bag were pulled together and rolled down against the alfalfa. The pallet was then placed in guide rails above the bag and the inner frame of the cart was inverted (rotated 180°) so the bag rested upside down on the pallet. This allowed the pallet and form to slip from the frame with the pallet resting on the ground (see Figures 1 to 4).

The weight of the material in the bag sealed the bag against the pallet. The pallet, form, and bag were transported with the fork lift and placed in the storage area where the plywood forms were removed.

Another 10 bags were filled with chopped alfalfa and 10 bags were filled with chopped corn silage in September by a second method. The plywood forms were set directly on the pallet, and bags within the forms were filled from a flight elevator receiving silage from self-unloading wagons. With this method, the tops of the bags were tied with twine. Transportation to the storage area and the removal of the forms completed the operation.

Several general comments can be made concerning the study.

1. The bags were difficult to fill. Both methods of filling required someone manually spreading the material in the bag and tramping it to accomplish a satisfactory filling job.
2. Vinyl film (8 mil.) withstood the tramping and handling operation very well; polyethylene film (8 mil.)was not satisfactory.
3. It is difficult to fill a bag with chopped forage and obtain a package that will remain in an upright position on the pallet. (See Figure 5)
4. Bags filled with chopped corn will not retain their shape after the forms are removed even though the material has been tramped. (See Figure 6)
5. As the silage in the bags settled, the plastic film sagged to the ground around the pallet, where the folds filled with liquids.

In this study, the folds were attacked and punctured by insects (possibly crickets). The bags were opened the following March. In 40 of the 45 bags, spoilage was complete or nearly so. It was assumed that air entering the holes at the bottom of the bags was the major cause of spoilage.

Also, it was found that the silage in the top of the bags was rather dry while the silage at the bottom was saturated or standing in liquids. This was attributed to a "pumping" action in which water vapor was generated by heat of the en-

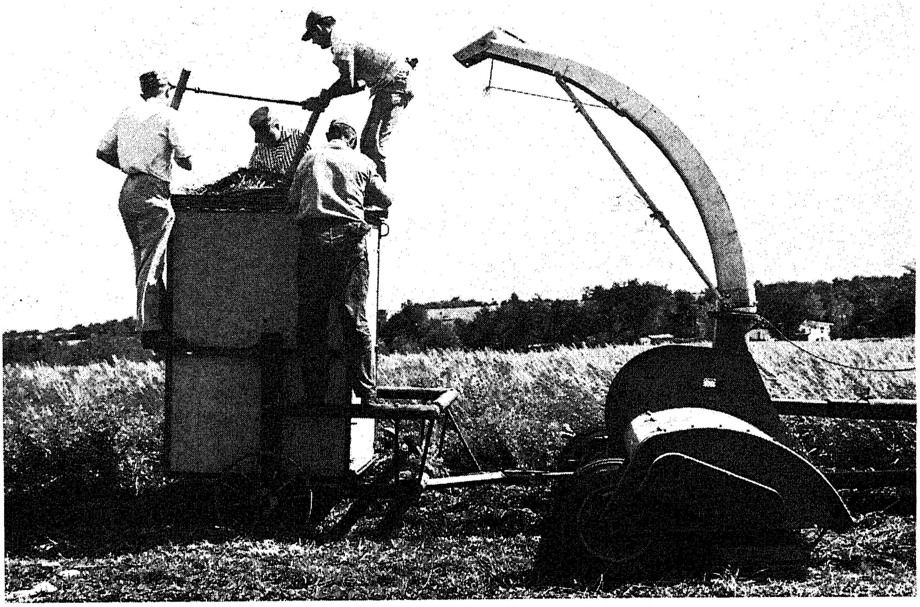


Fig. 1—Equipment used in Experiment No. 1 to hold the plastic film bag while it was filled from the forage harvester. The cart and exterior frame support a plywood form which holds the bag. The bag is held in place in the form by an adjustable frame which is shown being removed after filling.

Fig. 2—A 4-ft. x 4-ft. pallet was placed upside down in guide rails above the filled bag.

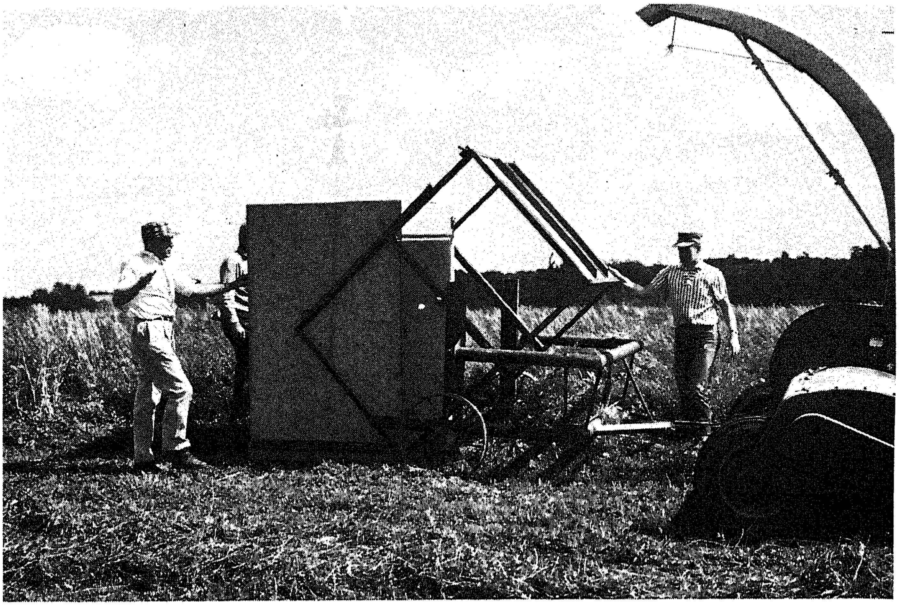


Fig. 3—The cart frame was rotated to invert the bag and plywood form onto the pallet.

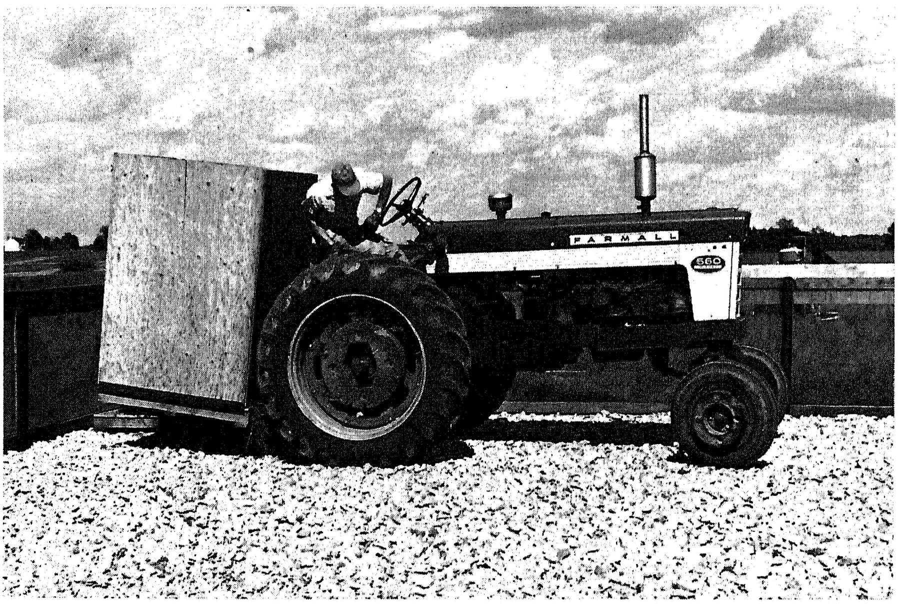


Fig. 4—The silage was transported to the storage area by a fork lift on the rear of a tractor. The plywood form was then removed.

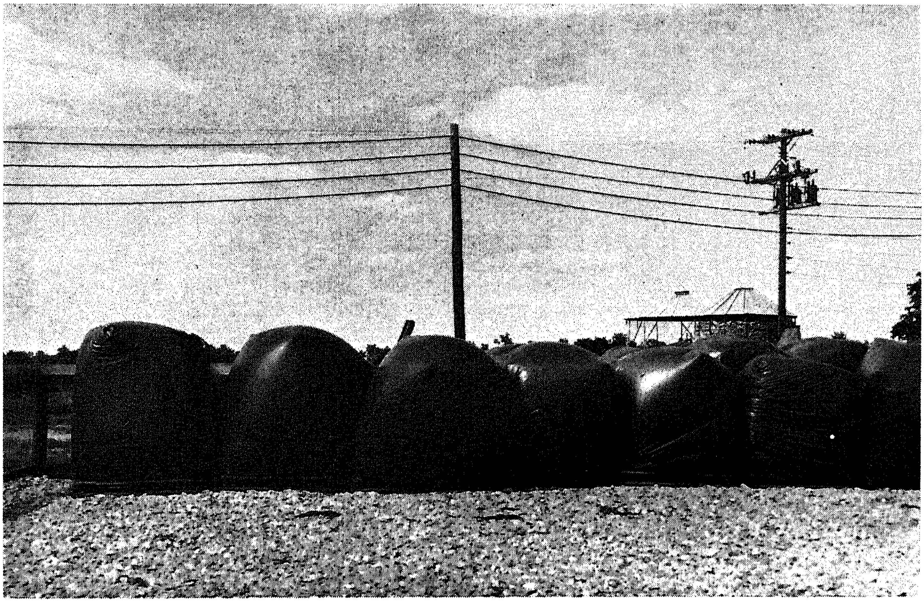


Fig. 5—Alfalfa silage in vinyl bags in the storage area. Gas from the ensiling process filled the bags for a few days after storage. Most of the bags finally leaned.

Fig. 6—Corn silage in plastic film bags. Most bags did not retain any semblance of the original shape even though the material was tramped during the filling operation.

siling process and by heat from the sun. The vapor condensed on the cooler inside surface of the bags, traveled down the bag wall and collected at the bottom.

Experiment 2

Twenty-four bags made of 8 mil. clear vinyl film were used in the next experiment as storage containers for chopped alfalfa silage which was cut in August. The bags were cylindrical in shape, 4 feet in diameter, 9 feet deep, and made with a flat bottom. The 9-foot side wall height was sufficient to allow filling the bags to a depth of six feet, gathering the bag material about the silage to make one tie, and then folding the excess material down for a second tie.

The alfalfa was field-chopped into self-unloading wagons. The chopped forage was hauled to the filling site, and emptied into a flight elevator. The elevator discharged either directly into the bag or into a hay baler which, in turn, discharged into the bag.

The baler was used to compress the alfalfa into chunks before it was tramped in the bags, in an effort to increase silage density. The baler was modified to reduce the cross-sectional size of the chunks to one-fourth the size of a regular bale slice. Figure 7 shows the alfalfa coming from the bale chamber in four separate sections. The chunks were the thickness of an ordinary bale slice.

Figure 8 is a view into the discharge end of the bale chamber showing the knife assembly used to quarter each bale slice. A stationary knife in the shape of

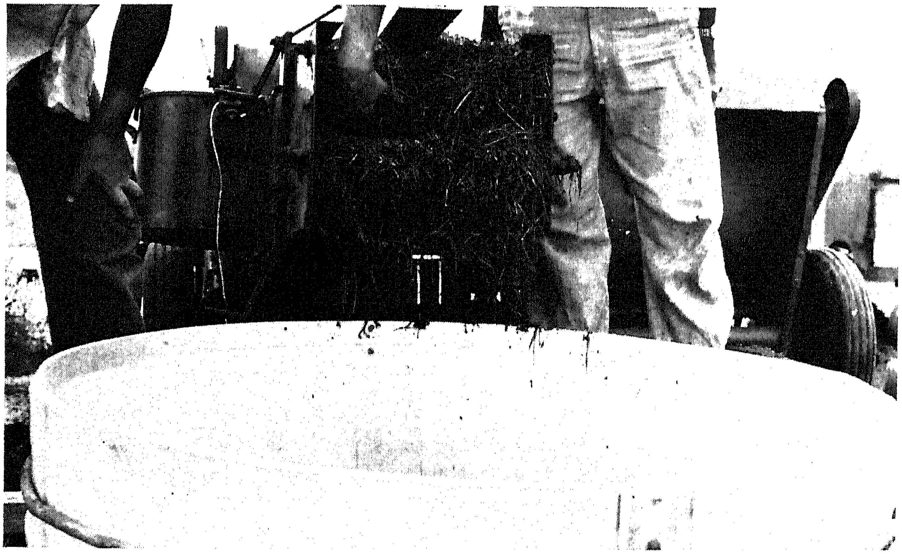


Fig. 7—Chopped alfalfa was compressed with a hay baler before it was placed in the bags. The baler was modified so that the forage emerged from the chamber in four separate sections. The tension hoop holding the bag in place in the form is visible in the lower left hand corner.

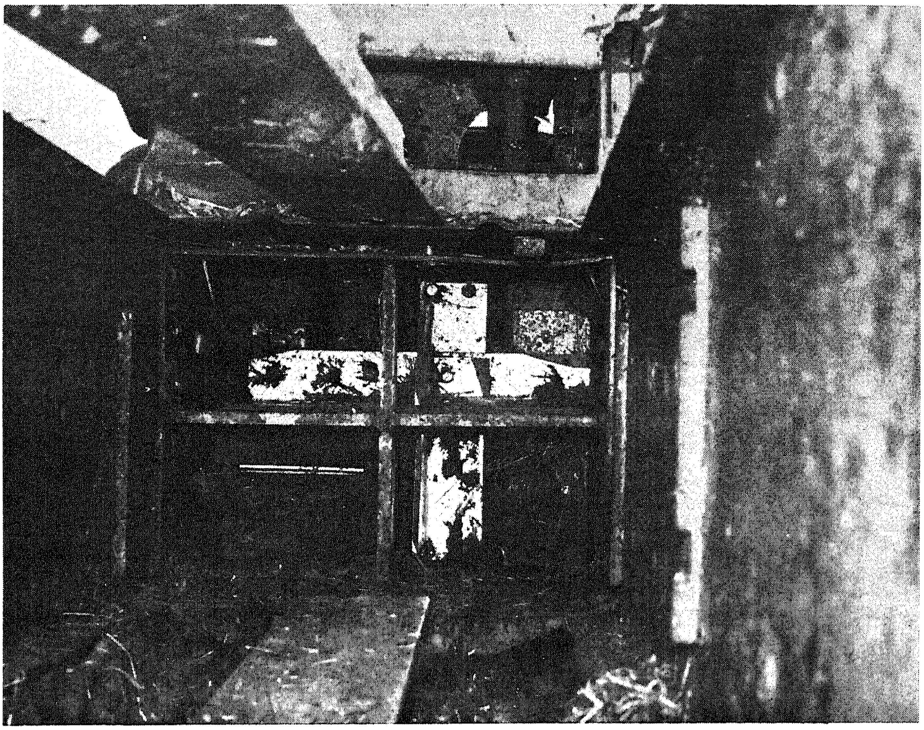


Fig. 8—A view into the discharge end of the baling chamber showing the stationary knives in the chamber and the moving knives on the plunger head that sliced the forage into four sections.

a cross was installed in the chamber, and moving knife sections were fastened to the end of the plunger. The needle assembly was removed from the baler.

The bags were suspended in a specially built form made of aluminum framing with fiberglass walls (see Figure 9).** The cylindrical form was made in two sections that were hinged and latched to each other so that the form could be opened to allow the bag to be removed. A pallet was placed in the bottom of the form to support the bottom of the bag during filling, and to provide a means of transporting the filled bag. A tension hoop made of plastic tubing and screen door springs held the bag in place in the form. The hoop is shown in Figure 7.

The majority of the bags were filled with alfalfa that was chopped directly from the standing crop. The remaining bags were filled with alfalfa that was wilted in the swath before chopping. A flail-type forage harvester was used. The moisture of the direct cut material ranged from 73 to 78 percent while that of the wilted material varied between 51 and 60 percent.

**Marvis Gillum, presently Agricultural Engineer with the South West Cotton Gin Laboratory, ARS, USDA, Las Cruces, New Mexico, designed and constructed this form.

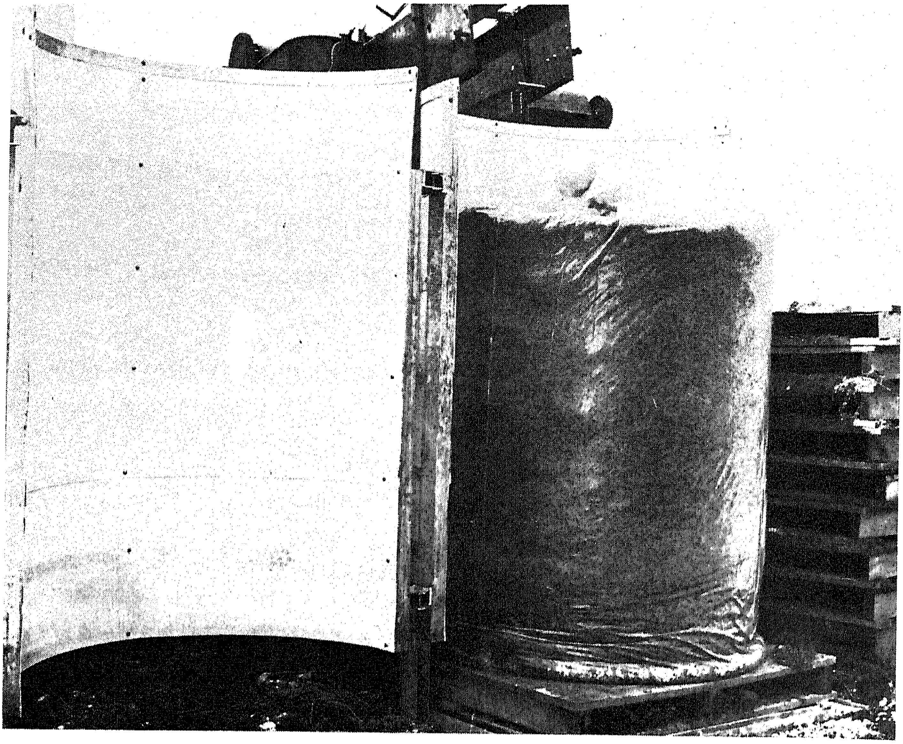


Fig. 9—The compressed chunks of forage from the baler were tramped in the bags which were suspended in the cylindrical form. Form walls are of fiberglass. The form opened to permit lifting the pallet and filled bag with a fork lift.

The direct cut material that was compressed with the baler before it was tramped in the bags had a bagged density of approximately 26 pounds per cubic foot. The bagged density of the direct cut alfalfa that was placed in the bags with the elevator was 22 pounds per cubic foot. Bags filled to a depth of five feet contained 62.6 cubic feet of silage. At a depth of five feet, the bags contained approximately 1635 pounds of silage when the alfalfa was compressed with the baler, and approximately 1385 pounds when they were filled from the elevator.

Very little difficulty was encountered in carrying the bags with a special attachment on the tractor lift (see Figure 10). There was only a small amount of clearance between the pallet and the ground, and irregular surfaces caused some difficulty.

The first few bags were filled to a depth of six feet. Those filled with direct cut material began to lean and within a few hours had toppled over. Those filled with wilted material remained upright. When the silage depth was reduced to five feet, the bags of direct cut material did not topple over although some of them were leaning within a day or two after filling. A wooden post was set up-

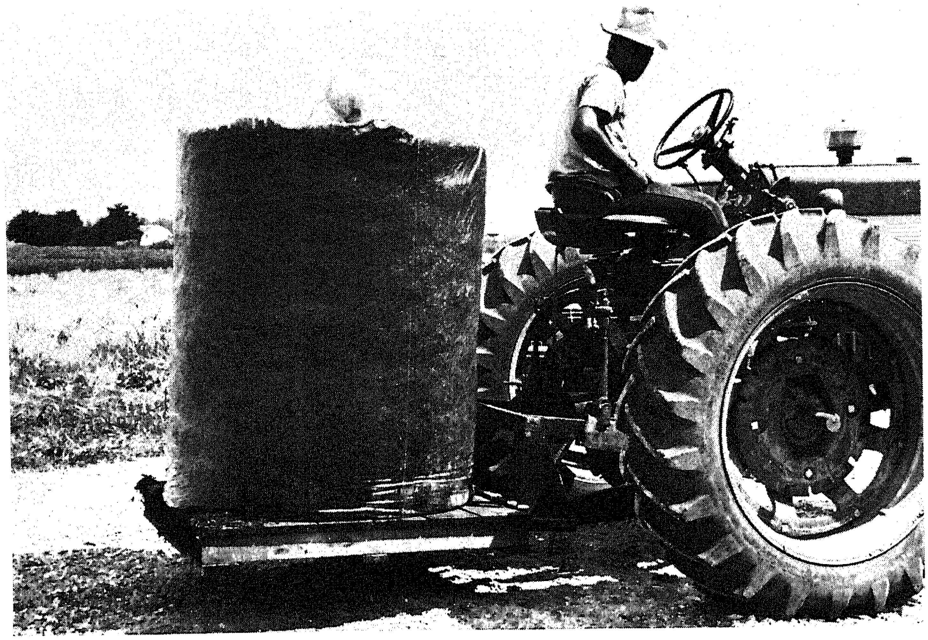


Fig. 10—The bags were transported as shown. The 4-ft. diameter bag filled to a depth of 5 ft. contained between 1600 and 1650 pounds of direct-cut alfalfa.

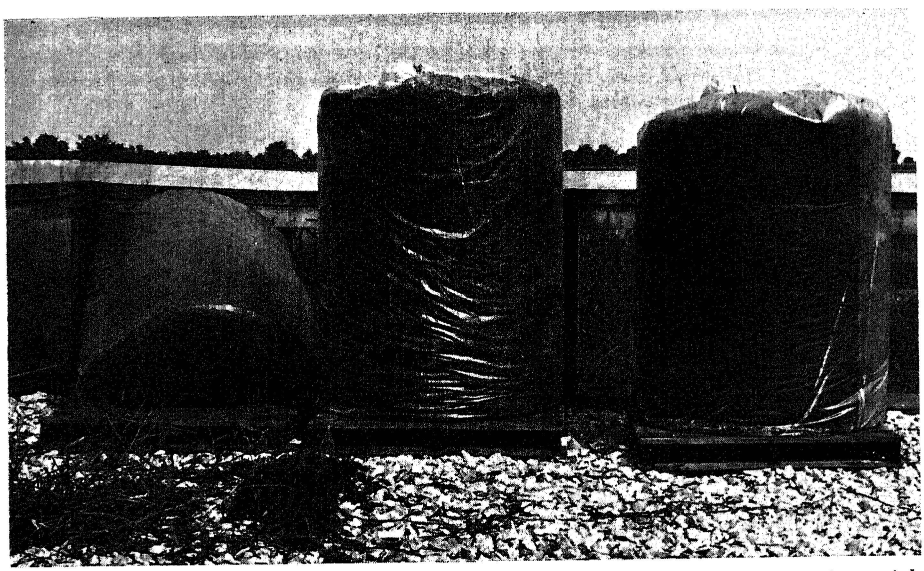


Fig. 11—Bags filled to a depth of 6 ft. with direct cut alfalfa (left) did not remain upright. Bags filled to a depth of 6 ft. with wilted alfalfa (center bag) and to a depth of 5 ft. with direct cut alfalfa (right) did not topple over, although some did lean. The bags are 4 ft. in diameter.

right in the center of many of the bags, but there was no apparent benefit from this addition.

In the filling operation the bale chamber protruded over the edge of the bag during the filling operation. This made it difficult to tramp the top foot or two of material along that edge to the same degree as the rest of the bag. In nearly every instance, the bag fell or leaned in the direction opposite to this edge. This is possibly explained by the poorer packing next to the baler or elevator during the filling operation, which caused the bag to lean toward the side with the greatest pressure on the bag wall.

The use of clear plastic in this study made it possible to observe the condensation on the inside of the bag walls (see Figure 12). The formation of condensate began within a few hours after storage and continued to some extent for several weeks. Half of the bags were stored in a building to minimize the heat from the sun.

Some condensation could be observed through the walls of the clear plastic bags stored in the building. A number of the bags had a small accumulation of liquids in the bottom, but no spoilage appeared as a result of this accumulation.

The outer edge of the silage stored outdoors was bleached by the sun and lost its green color, while the silage in the building retained its color. The con-

Fig. 12—Condensation on the inside surface of the bags is visible in this close-up of a filled bag. The condensate ran down the bag wall, collecting in the folds at the bottom of many of the bags. The folds resulted from the settling of the silage.

densate formed in the bags stored outside was clear in most of the bags, while that formed in the building had green color. This is evidence that the liquids found in the bottom of the bags is caused primarily from condensate and not from liquids draining from the silage.

The bags were stored in areas that were considered rodent proof. To control insect damage, the areas were sprayed with a chlordane solution, and the pallets were wetted with the same solution before they were used. The lower edges of the bags were also sprayed after they were filled. No insect activity was observed.

Tables 1 and 2 indicate the condition of the silage when the bags were opened the following April, after 8 months storage.

TABLE 1--SILAGE STORED INSIDE BUILDING, EXPERIMENT NUMBER 2

		Condition of Silage - After 8 Months Storage			
Bag No.	Initial Moisture Content %	Percent Good Silage in Bag	Moisture Content*	pH*	Notes
1	60	100	61	4.6	Wilted silage.
4	77	100	75	4.4	
7	77	100	--	---	Some liquid accumulation in bottom of bag.
8	77	100	77	4.9	Small hole in bag bottom.
9	79	70	77	4.6	Poor tie on bag. Top foot molded.
11	77	100	75	4.3	
12	77	100	--	---	
15	51	100	49	4.1	Wilted silage.
18	73	100	--	---	
19	--	70	50	---	Top foot molded. Wilted silage left on wagon overnight before bagging.
21	73	100	74	4.2	
24	73	100	71-74	4.3	Bottom three inches of silage wet, but not slick.

*Moisture content and pH taken of sample of good silage in bag.

TABLE 2--SILAGE STORED OUTSIDE BUILDING, EXPERIMENT NUMBER 2

Bag No.	Initial Moisture Content %	Condition of Silage - After 8 Months Storage			
		Percent Good Silage in Bag	Moisture Content*	pH*	Notes
2	77	20	--	---	Several holes in top of bag - large amount of liquid in bag.
3	77	0	--	---	Bag fell over - split on seams.
5	56	50	55	4.7	
6	77	98	--	---	Bottom six inches very wet.
10	79	25	--	---	Excessive liquid accumulation.
13	77	75	74	---	Top foot of silage spoiled - mold spots elsewhere.
14	77	50	69	4.3	Top one-half very wet.
16	51	60	47	---	Wilted silage left overnight on wagon before bagging - top one-third moldy.
17	73	75	75	4.7	Top foot spoiled.
20	73	85	--	---	Spoiled area in center of top.
22	73	95	73	4.5	Wet area under tie.
23	73	95	--	---	Wet area under tie.

*Moisture content and pH taken of sample of good silage in bag.

The data in Table 1 indicate that, generally, the silage stored inside the building came out of storage in good condition. There was some spoilage in two bags.

The data in Table 2 indicate that the outside storage was unsuccessful. A great deal of this difficulty appears to have resulted from the deterioration of the clear plastic exposed to direct sun action. Deterioration of the bags was greatest where the bags were gathered to make the tie, and there was evidence that rain water entered the tops of the bags.

Fig. 13—A structure designed to provide shade for silage in plastic bags. The front panels were on the south side and were removable to permit placing the bags (on pallets) under the structure.

The pH in some of the bags had a value above 4.5. A pH above 4.5 indicates a less active fermentation and is often associated with butyric acid production. However, this silage had an agreeable odor. It was not slick and appeared to be good silage. Proximate analysis data for some of the silage are given in Table 3.

Experiment 3

The results of the first two experiments indicated that plastic bags, exposed to the elements, deteriorate. Silage in the clear plastic showed the most deterioration. The third experiment was designed to accomplish the following:

1. Storage in bags exposed to all elements was to be compared to storage under a shade structure.
2. An attempt was to be made to fill the bags in the field with material coming directly from the forage harvester.
3. A means was to be sought to compact the material in the bags without the necessity of manual tramping.
4. A new type of bag made of fiber and asphalt paper construction would be used and compared to the clear plastic bags.

The 30 feet by 20 feet, corrugated sheet-metal pole frame building used as the shade structure is shown in Figure 13.

TABLE 3--PROXIMATE ANALYSIS OF FORAGE* AS ENSILED AND AS SILAGE

			% Moisture Wet Basis	% Protein of Dry Matter	% Fiber of Dry Matter	% Ash of Dry Matter	Storage Condition	Sample pH
Bag #1	As Bagged		67.3	22.4	25.6	8.1	Sheltered	---
Bag #1	After Storage	Top**	68.1	22.7	28.0	8.7	Sheltered	4.6
Bag #5	As Bagged		62.4	21.2	26.5	7.3	Exposed	---
Bag #5	After Storage	Bottom	65.2	21.9	27.7	8.6	Exposed	4.7
Bag #9	As Bagged		84.3	22.4	22.5	13.7	Sheltered	---
Bag #9	After Storage	Middle	84.4	22.4	24.0	16.4	Sheltered	4.6
Bag #11	As Bagged		84.3	21.7	24.0	10.0	Sheltered	---
Bag #11	After Storage	Top	82.6	21.7	25.9	9.6	Sheltered	4.3
Bag #15	As Bagged		56.4	20.9	27.4	8.4	Sheltered	---
Bag #15	After Storage	Middle	55.8	22.6	25.3	9.7	Sheltered	4.1
Bag #21	As Bagged		79.7	22.4	22.2	8.3	Sheltered	---
Bag #21	After Storage	Top	81.4	22.8	24.4	9.4	Sheltered	4.4
Bag #21	After Storage	Bottom	81.6	22.3	24.4	9.0	Sheltered	4.1

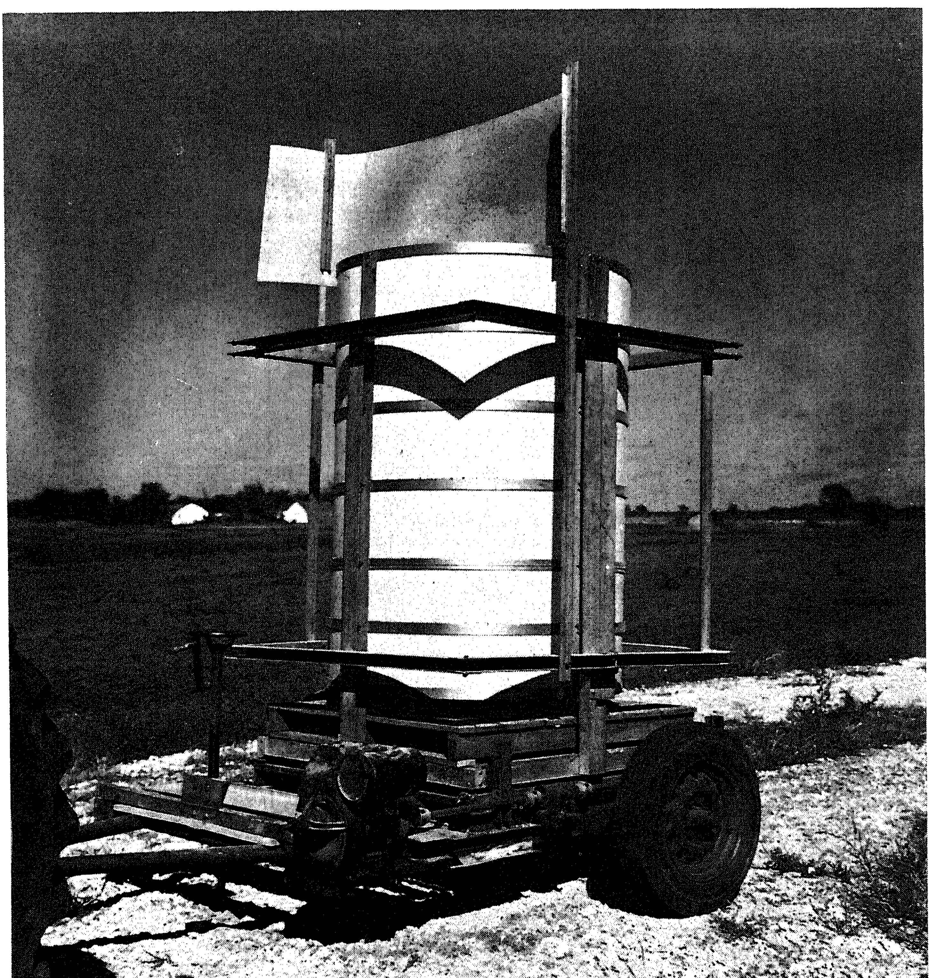
*Forage--predominantly alfalfa with some orchard grass.

**Sample for analysis taken at the described position in each bag at the time the bags were opened.

The stationary form used for filling the bags in Experiment 2 was redesigned to fit on a wheeled frame to be trailed behind the field harvester (see Figure 14). A pallet could be slipped into the form and a bag suspended in place and held there by a tension hoop that was placed around the top and over the portion of the bag that was rolled over the upper edge of the form. A deflector strip above the form prevented material from blowing over the bag during filling.

A device was designed to lift the form, bag, and pallet a short distance and then drop them. The purpose of the device was to spread the material in the bag and to compress it to a greater density than could be obtained by letting the material fall freely from the harvester spout. The drive is shown in Figure 15.

Fig. 14—A portable form that was used to support the plastic bag during field filling. The bag was suspended in the form with the top of the bag rolled over the upper edge of the form. The bag was held in place by a tension hoop.



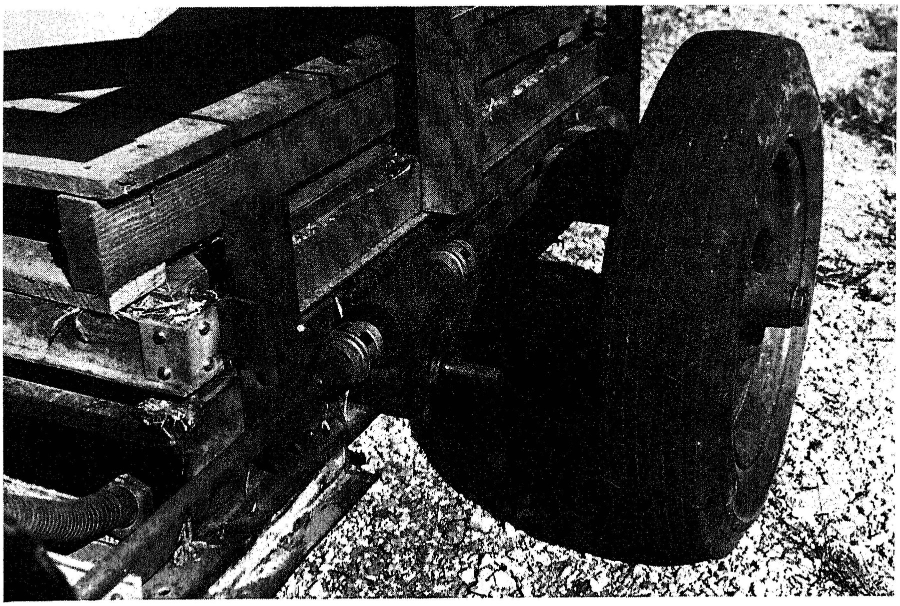


Fig.15—A close-up of the drive that turns two cross shafts passing under the form. Cams on the cross shaft lifted the form, bag, and pallet which were then dropped to jar and compress the material in the bag.

This device proved ineffectual, and after attempting to use it on the first few bags it was abandoned and the bags were tramped for compaction.

Sixteen cylindrical bags, with a diameter of 4 feet were filled to a depth of 5 feet with chopped alfalfa silage during June and July. Eight of the bags were made of 8 mil. clear vinyl film and eight were of a fiber and asphalt paper construction. The bags contained approximately 1200 pounds of silage.

Figures 16 and 17 show a paper bag that has been filled and removed from the form. The cap was sealed with masking tape as shown. All the bags were handled with the fork lift shown in Figure 18.

Eight other paper bags were filled with chopped corn silage in August. These bags were filled at the farmstead by means of a flight elevator. The silage was brought from the field in a self-unloading wagon. No form was needed to hold the bags, which held approximately 1500 pounds of corn silage. The paper bags filled with corn silage remained standing after filling, which was something that had never been accomplished with plastic bags.

Half of the bags in each category were stored in the shaded structure shown in Figure 19. The other half were stored in the open. All storage was protected from rodents.

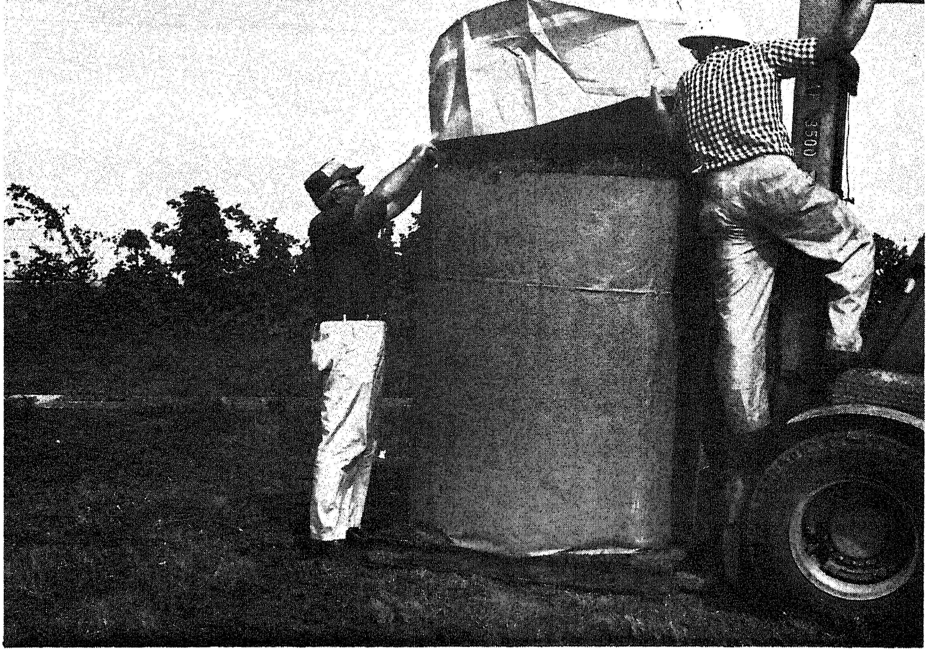
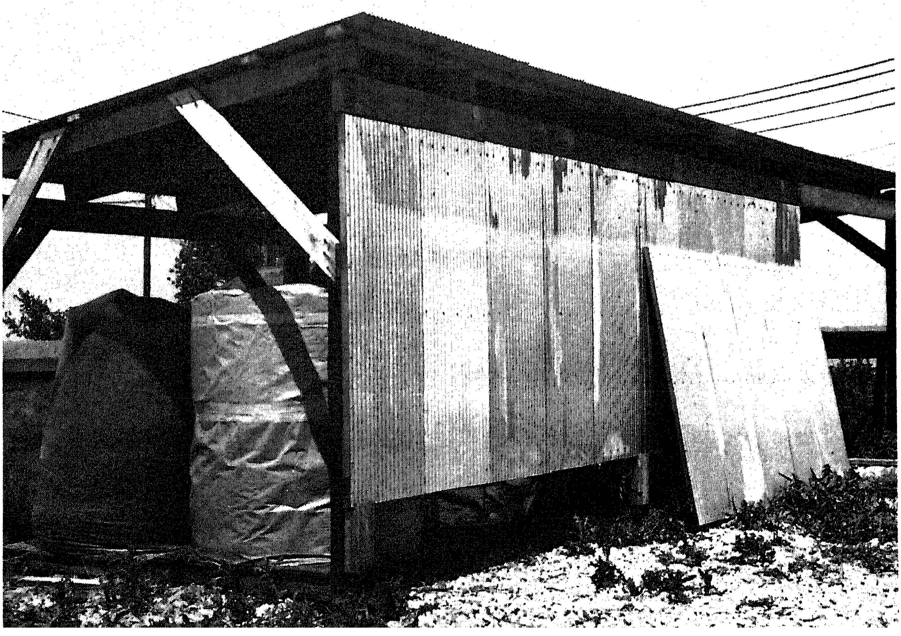


Fig. 16—Bags constructed of a fiber and asphalt paper were filled with both chopped alfalfa and corn silage. A cap is shown being placed on the bag.

Fig. 17—The cap was sealed in place with three layers of masking tape.

Fig. 18—The bags, 4 feet in diameter and 5 feet tall, were handled by a fork lift. The bags held approximately 1200 pounds of chopped alfalfa.

Fig. 19—Storage in the paper bags was compared to storage in clear vinyl bags. Half of the bags tested were stored in the shade structure shown and half were stored in the open.



The bags were opened in April the following year and the condition of the silage and other pertinent comments are given in Table 4.

The paper bags were moderately satisfactory for the storage of corn silage. The bags remained standing and retained their shape fairly well. The percentage of silage molded was small, but the mold was scattered throughout the bag. In many cases the mold was a red mold. The corn silage had a bland odor and extremely low pH values (3.6 to 3.8).

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2. Briggs, Rodney A., "Plastics for Silage," *Minnesota Farm and Home Science,* Volume 1, XIV, No. 3, May 1957.
3. Sprague, M. A., "Plastics Fill a Need," *What's New in Crops and Soils,* Volume 8, No. 1, October 1955.

TABLE 4--REPORT ON SILAGE STORED IN EXPERIMENT NUMBER 3*

Bag No.	Silage Material	Date Bagged	Bag Material	Storage Location	Percent Good Silage	pH**	Notes
1	Alfalfa	6/26	Clear plastic	Shade structure	65	4.25	No holes in bag
2	Alfalfa	6/26	Clear plastic	Shade structure	95	4.15	No holes in bag
3	Alfalfa	6/28	Clear plastic	Shade structure	90	4.30	No holes - spoilage on top
4	Alfalfa	6/28	Clear plastic	Shade structure	85	4.40	No holes in bag
13	Alfalfa	6/28	Clear plastic	Outside	50	4.5	Top of bag deteriorated
14	Alfalfa	7/1	Clear plastic	Outside	20	---	Top of bag disintegrated - large holes
15	Alfalfa	7/1	Clear plastic	Outside	90	4.5	Spoilage at top - no holes
16	Alfalfa	7/1	Clear plastic	Outside	20	---	No holes visible
5	Alfalfa	6/27	2 ply paper, uncoated	Shade structure	50	4.4	Deterioration on top and side of bag
7	Alfalfa	6/27	4 ply paper, coated	Shade structure	50	4.4	No holes - heavy mold on top and side
9	Alfalfa	6/27	3 ply paper, coated + polyethylene tube	Shade structure	55	3.5	
11	Alfalfa	6/27	3 ply paper, uncoated	Shade structure	55	4.35	Small hole in bag - lower one-half of bag stained through
6	Alfalfa	6/27	2 ply paper, uncoated	Outside	?	---	Inside of bag showed some deterioration
8	Alfalfa	6/27	4 ply paper, coated	Outside	60	4.6	Top 40% spoiled - bag in good condition
10	Alfalfa	6/28	3 ply paper, uncoated + polyethylene tube	Outside	50	4.7	Hole in top of bag (3" diameter)
12	Alfalfa	6/28	3 ply paper, uncoated	Outside	70	4.5	Bag deteriorated around bottom
17	Corn	8/16	4 ply paper, coated + polyethylene tube	Shade structure	90	3.8	Bag in good condition
18	Corn	8/16	2 ply paper, uncoated + polyethylene tube	Shade structure	80	3.6	Discoloration on outside of lower one-half of bag

TABLE 4--Continued

Bag No.	Silage Material	Date Bagged	Bag Material	Storage Location	Percent Good Silage	pH**	Notes
19	Corn	8/16	3 ply paper, coated	Shade structure	97	3.6	Bag in good condition
20	Corn	8/16	4 ply paper, uncoated	Shade structure	85	3.6	Mold spots throughout
21	Corn	8/16	4 ply paper, coated + polyethylene tube	Outside	90	3.8	Mold scattered through bag
22	Corn	8/16	2 ply paper, uncoated + polyethylene tube	Outside	85	3.8	Some deterioration on bag top
23	Corn	8/16	3 ply paper, uncoated + polyethylene tube	Outside	95	3.7	Bland odor
24	Corn	8/16	4 ply paper, coated + polyethylene tube	Outside	90	3.9	Top of bag held water and deteriorated. Bland odor.

*All bags were opened on April 21 the following spring.

**pH taken of "good" silage.