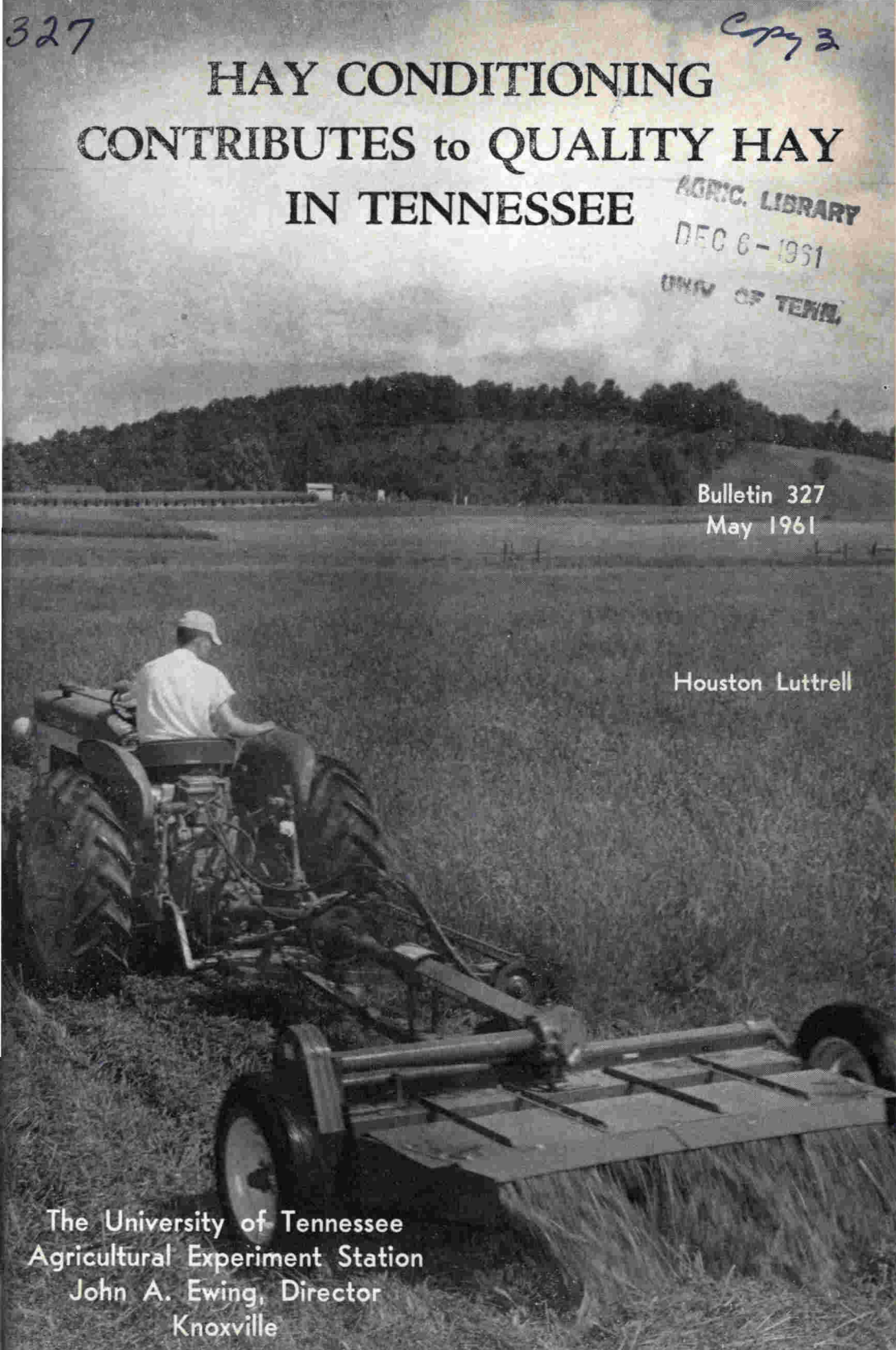
HAY CONDITIONING CONTRIBUTES to QUALITY HAY IN TENNESSEE



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Summary and Conclusions

● Experiments conducted in Tennessee during 1958, 1959, and 1960 indicate there is very little difference in the drying rates produced by the different types of conditioners when used on alfalfa. However, a crimper produced better drying than a crusher when used on soybeans and the crusher produced somewhat better drying than the crimper in alfalfa. The flail harvester, used as a conditioner, gave drying rates on alfalfa similar to drying rates of other conditioners as long as the forage was distributed on the ground broadcast for drying; windrowing reduced drying rates.

● The experiments showed, in general, that conditioning forage cut for hay shortened the period required to place the hay in storage by 1 day. Shortening the drying period from 3 to 2 days increases a farmer's chances of making hay without damage from rain by 55% in Tennessee.

● Delaying the conditioning operation longer than 15 to 20 minutes after mowing reduces the benefits of conditioning. Therefore, large fields should be mowed in tracts small enough so the conditioner, which operates one round behind the mower, will follow the mower within 15 to 20 minutes or less.

● Some good points to remember when using a hay conditioner are:

1. Don't wait too long in a recognized drying period to start cutting.
2. Cut the crop as near the proper stage of maturity as possible.
3. Consult your operator's manual for machine adjustments and operating instructions.
4. Condition the material within 15-20 minutes after mowing.
5. Adjust pressure rolls of the conditioner according to the type of hay. Smaller stems require higher pressures.
6. Adjust the deflectors on the conditioner so as to get the best fluffing.
7. Operate the conditioner with as high clearance as possible to avoid trash, rocks, and soil.
8. Operate the pto (power take-off) at recommended speed.
9. Rake the material at a moisture content which will prevent unnecessary leaf loss and allow drying to continue. Normally 30% to 35% moisture content is best for raking, but this varies according to the hay.
10. Store the hay as soon as it is ready.

CONTENTS

HAY CONDITIONING CONTRIBUTES to QUALITY HAY IN TENNESSEE

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Introduction

High-quality hay in the barn is the objective of every farmer when he starts a hay-making operation. High-quality hay is made from weed-free forage cut at the proper stage of maturity, then dried and handled so as to produce a product that is leafy and green in color. The stems are soft and pliable. It is free from mustiness and mold and has a pleasing fragrance.

The method used to produce high-quality hay is to reduce the moisture content of the green plants to a level which will allow the hay to be stored safely and retain as much of its original feed value as possible. A generally-accepted safe moisture content for hay being placed in storage is 20%. Hay stored with too much moisture will ferment and mold.

Quality hay production can be accomplished by artificial curing, with or without heated air, and by field curing. Field-curing is the most commonly used method in Tennessee. However, some farmers use artificial drying equipment. Normally, it takes from 2 to 3 days of good drying conditions to field-cure alfalfa, and 3 to 5 days to cure crops such as soybeans and oats. When a farmer uses the field-curing method, he must try to avoid bad weather conditions—especially rainfall—during his hay-making operation.

Losses

There are always some losses when field curing hay, but when weather conditions are favorable, losses can be minimized with proper management. The losses which occur are: loss of leaves and fine stems by shattering; loss of nutrients by fermentation; loss of nutrients by bleaching; and loss of water-soluble nutrients by leaching during a rain.

Shattering losses occur when the leaves become too dry. The stems do not dry as fast as the leaves. Therefore half or more of the leaves may be lost by shattering during handling operations while waiting for the stems to dry enough for storage. Alfalfa leaves, for instance, contain 70% of the protein and as much as 90% of the minerals and vitamins of the green forage and they also contain less fiber and more easily-digested nutrients than do the stems (1). According to a University of Minnesota report, nutrient value lost by leaf shatter can amount to an equivalent of 700 pounds of linseed oil meal plus 250 pounds of corn per acre per year in alfalfa hay that still qualifies as U. S. #2. On a dollar basis this loss amounts to approximately $35 per acre per year.

Fermentation in the field causes some of the organic nutrients—especially the sugars and starch—to be oxidized to carbon dioxide and water; thus they are lost. Fermentation also is highly destructive of the carotene in hay (2). Fermentation will occur excessively after the hay is placed in the mow if it has not been cured properly; however, if the hay has been well-dried, the losses of dry matter will usually not exceed 5% to 7% in the mow.

Bleaching, by prolonged exposure to the sun, will result in the loss of nearly all of the carotene. In general, the amount of carotene in hay is proportional to the greenness in color. Green-colored hay is nearly always rich in carotene and straw-colored or brown hay contains little carotene (2).

Hay leaches severely when it has dried out considerably before rain comes, and when the rain is so heavy that the hay is thoroughly soaked and washed. At least 20% of the protein and considerably more of the nitrogen-free extract can be lost by leaching (2). However, rain soon after the crop is cut does not cause much loss.

The total loss of nutrients in hay during field curing and subsequent storage will vary according to weather conditions and management of the operations. Under favorable drying conditions and proper methods of handling, the total loss of dry matter from the green crop to the manger should not exceed 20% to 30% for legume hay and 10% to 15% for grass hay (2).

Weather and Hay-making

The elements of weather which influence field drying are temperature, humidity, wind, sunshine, and precipitation. Weather

forecasters can predict weather conditions with a reasonable degree of accuracy 1 to 2 days in advance. However, longer predictions are less reliable. An analysis of Tennessee weather data kept for a 38-year period at Knoxville disclosed that on the average each year there were approximately 6 five-day, 9 four-day, 14 three-day, 22 two-day and 99 one-day periods with no expected rain during hay-making months. Thus, reducing the field curing period of hay from 3 days to 2 days increases a farmer's chances of curing hay without rain by 55%. Since nothing can be done about the weather, farmers must work around it and improve their methods of processing and handling to get the best quality hay possible.

Hay Conditioning

Basic Principle of Hay Conditioning

Hay conditioners were used experimentally as early as 1930. Most hay conditioners in use today have been manufactured during the last 5 years. Hay conditioners consist basically of two rollers, 4 to 12 inches in diameter, 70 to 80 inches in length, held together by springs. These rollers are arranged on a frame so hay can be picked up from a swath, crushed, and dropped to the ground in a fluffy manner as the machine travels over the ground (See cover photo).

The basic principle upon which a conditioner works is to crack the stems of hay so air can circulate near the inner portions of the stem (Figure 1). This inner circulation speeds the drying rate of the stems so they can dry nearly as rapidly as the leaves. Thus, there is a shorter waiting period for the hay to dry.

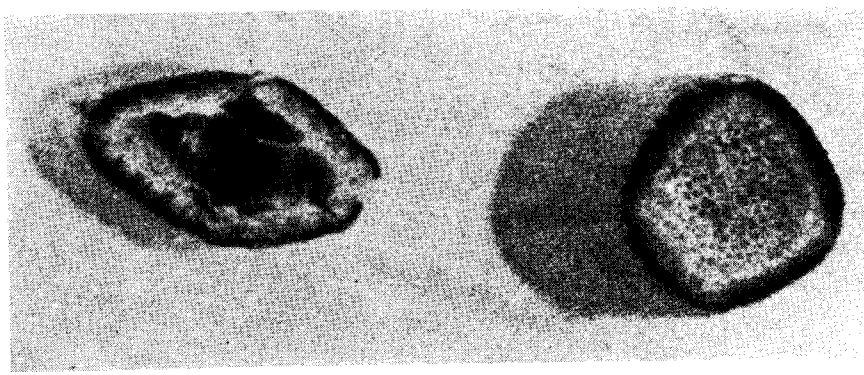
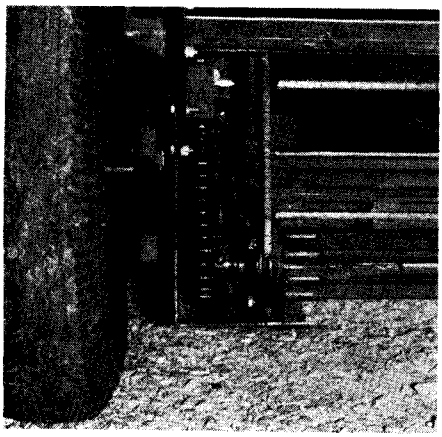


Figure 1. This cross-sectional view is of alfalfa stems, with the conditioned stem on the left.

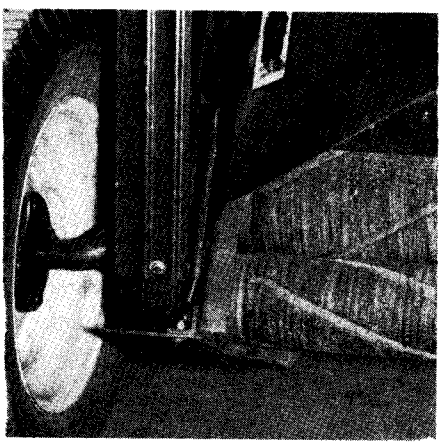
Types of Conditioners

Conditioners are classified into three types: 1) crimper, 2) crusher, and 3) flail (see Figure 2). The crimper consists of two

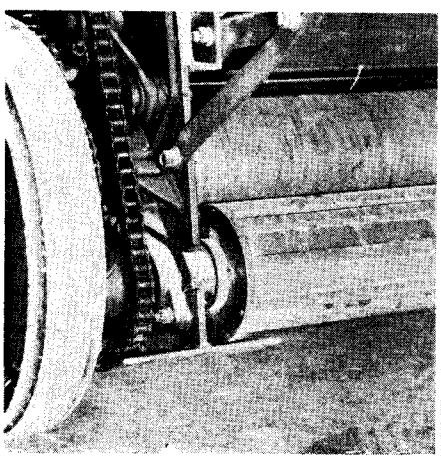
Figure 2. Views of the different types of conditioners.



a. Crimper with fabricated rollers



b. A crusher with two rubber rollers.



c. A crusher with one smooth rubber roller and a ribbed roller.

d. The flail harvester with hay conditioner attachment.

corrugated rollers meshing together like two gears. Some rollers are made of malleable cast iron, while others are fabricated from steel bars welded axially on the roller assembly to form the teeth. These machines produce a crimped effect on the stems and crack them at intervals of ½ to 1½ inches apart.

Smooth-roller machines and machines on which a smooth roller runs against a ribbed roller are referred to as crushers. A variety of roller types are being used in the design of crushers, and the effect produced on the stem by a crusher varies according to the type of rollers the machine has on it. Some crush the entire stem and others crush only short segments. Both the crimper and the crusher have adjustments which control roll pressure and operating height above the ground. Some manufacturers are equipping their conditioners with windrow shields and practically all units have deflecting shields to produce a fluffing effect as the material is discharged onto the ground. Both crimpers and crushers can be combined with mowers to form a unit which can be operated by one tractor (see cover photo). They can also be operated separately from the mower on another tractor (see Figure 3).

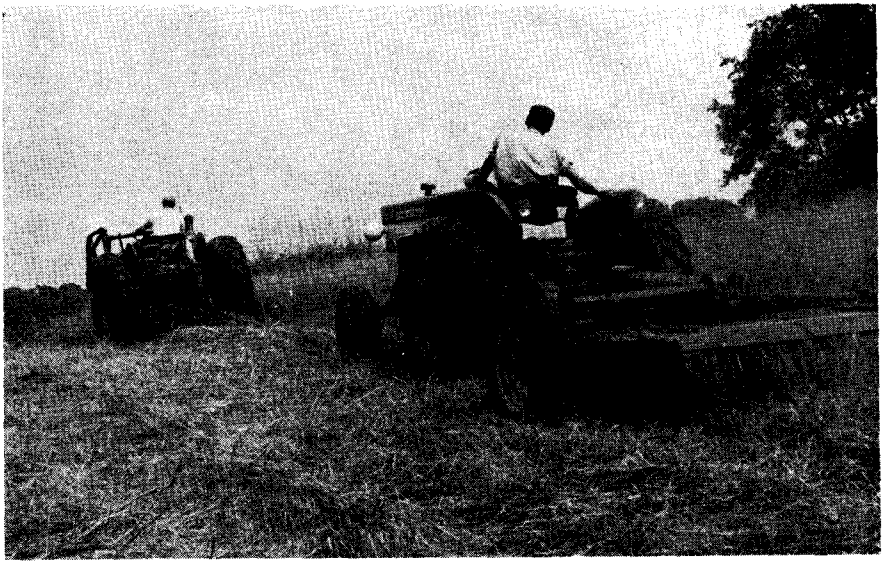


Figure 3. Mowing and conditioning with two tractors.

The flail-type forage harvester produces a crushing and lacerating action on stems during the cutting operation. Consequently, it can also be classified as a conditioner. Forage can be cut with this harvester, discharged to the ground broadcast, or windrowed for drying. Some machines, such as the one shown in Figure 2d, permit as many as three windrows to be placed side by side in a width narrow enough for a baler to pick up all of them with one pass.

Horsepower Requirements

The horsepower requirements for conditioners vary among different types of machines. Power requirements for smooth-roll conditioners running in alfalfa that yields about 3.6 tons per acre varies between 4 and 7 horsepower; however, a crimper usually requires less than 4 horsepower under the same conditions (3). The power requirement for the flail harvester may be more than 30 horsepower, depending upon the rate of feeding.

The Purpose of the Study

The purpose of this study was 1) to determine how different types of conditioners affect the drying rate of forage being field-cured for hay under Tennessee weather conditions; 2) to determine how soon after mowing hay should be conditioned for best results; 3) to determine the feasibility of using hay conditioners in Tennessee for making hay in 1 day; and 4) for wilting grasses which will be made into silage.

Procedure

The experiments were conducted during 1958, 1959, and 1960 in the Knox county area of Tennessee. Alfalfa, soybeans, and oats were used in the study. Plots were marked off in the areas of the field which were typical from a standpoint of the yield, drainage, slope, etc.

Two adjacent swaths, approximately 200 feet long, were conditioned by each conditioner. Samples, consisting of about 100 grams of material each, were taken periodically from each treatment and placed in cans for moisture determination. The samples were weighed immediately, then oven-dried and weighed again to determine the moisture content on a wet basis. Each time samples were taken, a record of the temperature, relative humidity, wind, and cloud cover was made.

Results and Discussion

Comparative Experiments

In order to compare the drying rates produced by different types of conditioners, an experiment was conducted on alfalfa in 1959. The results of this experiment are shown graphically in Figure 4. The treatments in this experiment involved a crimper,

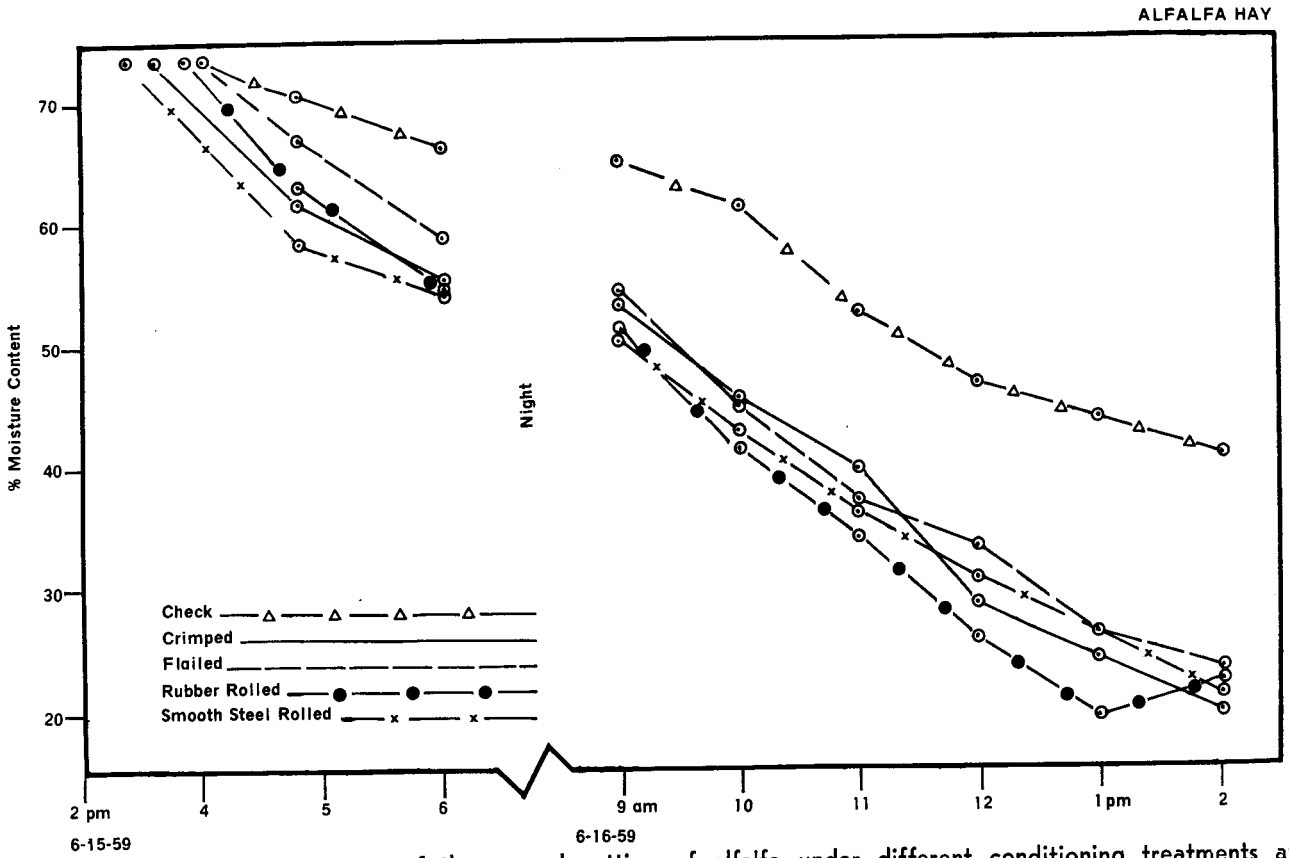


Figure 4. Mean moisture content of the second cutting of alfalfa under different conditioning treatments at Knoxville, Tennessee.

a rubber-roller conditioner, a smooth-steel roller conditioner, and a flail harvester. The hay material which was harvested with the flail harvester was broadcast on the ground for drying. The forage was cut on the afternoon of June 15, 1959.

The moisture content of the control treatment was consistently higher than that of all other treatments. The material conditioned with the rubber-roller conditioner dried somewhat faster than the material conditioned with the other machines, but there was no significant difference at the 95% level between any of the conditioners used. There was a highly significant difference, however, between the moisture content of the conditioned and non-conditioned hays.

The weather conditions throughout the experiment are shown in Appendix I. All conditioned plots in this experiment were ready for baling on the day after cutting. The unconditioned material contained 40% moisture at 2 p.m. on the day after cutting, when sampling was stopped. There was not sufficient drying time to lower the moisture content of the unconditioned material to a safe storage level by the second night.

Soybeans

Several problems are involved in making good hay from soybeans cut at the proper stage of maturity. Soybeans usually require from 4 to 5 days to cure in the field, and the chances of getting a 5-day period without rain at harvest time are low. Many of the nutrients contained in the leaves and stems of soybeans are usually lost by bleaching, leaching, and shattering during the long field-curing process.

Figure 5 shows graphically the results of an experiment conducted on soybeans using two types of conditioners on August 26 and 27, 1958. The soybeans on the area had stems averaging ⅜-inch in diameter at a height of 2 inches above the ground. The yield was relatively high for Tennessee conditions. A crimper and a rubber-roller conditioner were used. The moisture content of the conditioned material was consistently lower than that of the non-conditioned material. The crimped material had a consistently lower moisture content than the rolled material.

Probably this difference occurred because the crimper broke the large stems open at intervals of 1 and 1½ inches, thus permitting more air circulation to take place immediately inside the crimped

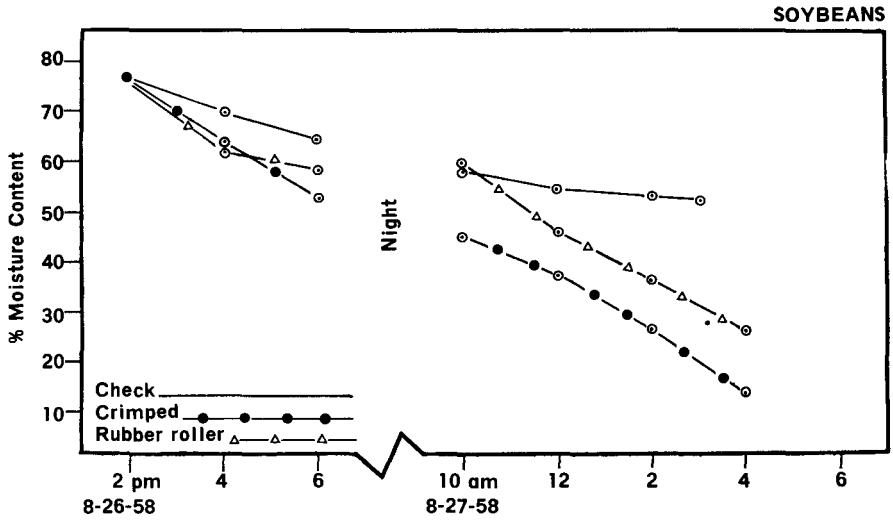


Figure 5. Mean moisture content of soybean hay under different conditioning treatments in Knox County, Tennessee.

stem than in the crushed stems. The crimped material dried to 20% moisture by 3 p.m. on the day after cutting. The rolled material contained 30% moisture at this time with the check treatment containing 53% moisture. Appendix II shows the weather conditions during the experiment.

Oats

Since oats are frequently cut for hay in Tennessee, a test was conducted to learn if conditioning affected the drying rate of oats. Since very little difference was found in earlier tests between any of the conditioners, only one conditioner was used for this experiment. The results of the test are shown in Figure 6. The oats were cut shortly after 11 a.m. on May 31, 1960. Sampling was continued through 6:45 p.m. on the second day after cutting. The conditioned material was down to 20% moisture level by 2:30 on the day following mowing, whereas the material which had not been conditioned still contained 35% moisture content at 6:45 p.m. The weather conditions throughout this experiment are given in Appendix III.

Delayed Conditioning

Succulent stems crush better than wilted stems. Since a conditioner must be run one round behind the mower so that the tractor

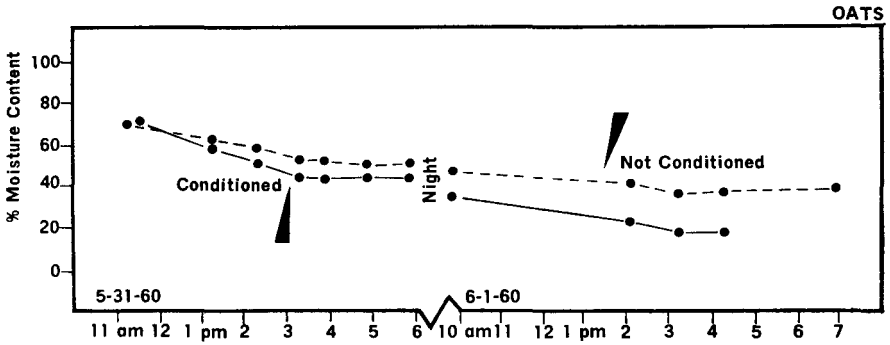


Figure 6. Mean moisture content of oat hay under different conditioning treatments in Knox County, Tennessee.

will not run over the conditioned swath, the forage will wilt before it is conditioned if the field is too large. An experiment was run to determine the effects of delaying the conditioning treatment for various intervals of time after mowing. This experiment was conducted on alfalfa which was mowed shortly after 11 a.m. on September 14, 1960. The plots were set up in rapid succession so there would be a minimum amount of delay between treatments. The moisture contents of the materials which were conditioned with no delay and with a 10-minute delay were consistently lower than those of the materials in the other treatments (Figure 7). In this particular experiment, the material conditioned within 10 minutes after mowing was ready for baling by 2 p.m. the day after mowing, whereas the material in the other plots was not ready for baling in time to put it into the barn on the day after mowing. Appendix IV shows the weather conditions during the experiment.

One-Day Experiments

If hay can be put in storage in one day, chances for producing high-quality feed are greatly increased. Therefore, attempts were made on May 5, June 8, and June 15, 1959 to cut and condition alfalfa hay during the morning and bale it the same day.

Fields containing 6 to 8 acres each were mowed and conditioned by 10 a.m. Good drying conditions were experienced during each of the three 1-day experiments. The hay made on May 5 and June 8 appeared to lack from 1 to 2 hours of drying time needed to be ready for baling on the same day. They both had to be baled on the day after mowing. On June 15 a sample was taken at 4:15

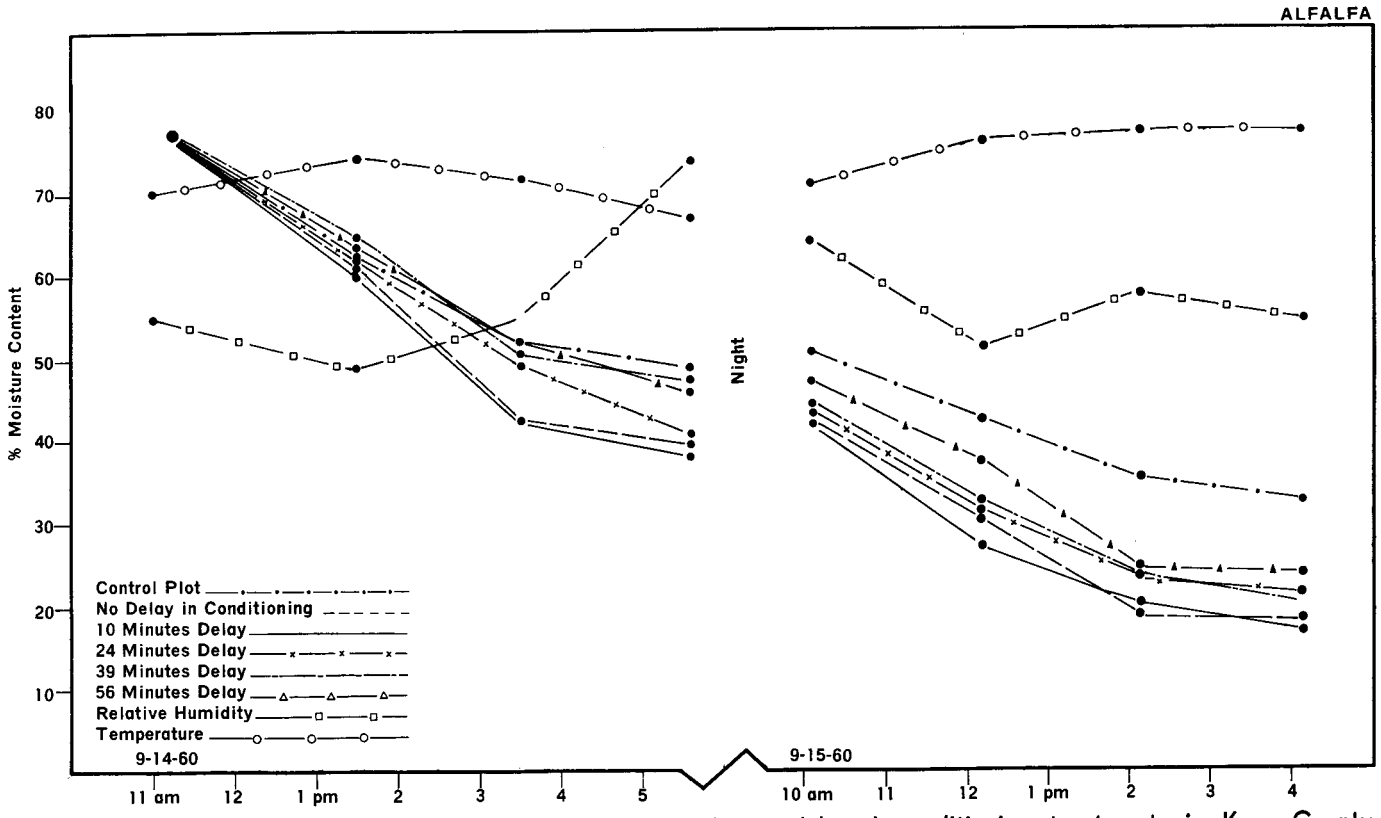


Figure 7. Mean moisture content of alfalfa hay under different delayed conditioning treatments in Knox County, Tennessee.

p.m., which indicated the average moisture content was approximately 20%. Observations made on other tests indicated that a crop of alfalfa conditioned after mowing will occasionally be dry enough for storing in 1 day.

Wilting Forage for Making Silage

Silage should be made from forage containing 65% to 70% moisture. Forage, such as grasses and alfalfa, usually contains 70% to 80% moisture standing in the field at the proper stage of maturity for harvest. Consequently, many crops are mowed and wilted in a swath or windrow before being chopped for making silage. Forage which was conditioned in the experiments conducted in Tennessee dried to 65% moisture content from 10 minutes to 2 hours sooner than forage which had not been conditioned. There was less than an hour gained in reducing moisture content to 65% in 8 of 9 of the experiments conducted with the conditioners. This variation of time is probably due to weather conditions and the kind of crop being harvested. Soybeans which had been conditioned showed the greatest time gain for wilting.

General Observations Of the Characteristics of Hay Conditioners

Crimpers

The crimpers used in the experiment did not have any difficulty in picking up the material from the swath except when the material was thin. Large weeds were picked up and passed between the rollers without clogging the machine. Rocks sometimes would pass between the rollers and would bend the crimping bars. When the crimper was operated below standard speed, wrapping of the hay material on the crimping rolls occurred in soybeans; but when the crimper was operated at the proper speed wrapping was not a problem. Some clippage of leaves and small stems was noticed when the material was run through a crimper.

The degree of fluffing could be controlled by adjusting the rear baffles on the conditioner. These baffles had to be adjusted according to the type of hay that was being conditioned.

Crushers

The crushers did not have any difficulty in picking up the material except in situations where the material was thin and when several large weeds were in the hay. Large weeds with a diameter of an inch or more lodged between the smooth rollers and prevented any additional material from passing between the rollers. The machine had to be cleaned when this happened. Rocks usually would not pass between the crushing rollers, but when they did, no damage was done. Very little wrapping of material around the crushing rolls was encountered. Wrapping seemed to occur only when the machine was not operated at the proper speed. The smooth steel roller machine used in the experiment had a pickup cylinder which would wrap material around it when the machine was permitted to creep into an adjacent swath, but there was no wrapping on the crushing rollers.

The rubber roller type conditioner snapped leaves and short stems off as the material passed between the crushing rollers. This clippage apparently was caused by the high roller speed on the machine. The smooth steel rollers did not seem to cause much clippage.

The baffles on the crushers were adjusted to control the amount of fluffing as the material was discharged onto the ground. The amount of fluffing depended upon the way the baffles were directed and also the kind of material which was being conditioned. When the material was thin a better fluffing action was observed with the windrow baffles set close together. However, when the material was heavy, fluffing was better when the material was permitted to fall back to the ground in a wide swath.

Flail Harvester

The flail harvester was used on alfalfa and oats. With the flail harvester there seemed to be considerable losses due to the material left on the ground after raking and baling. Nearly all of the heads of oats were shattered from the stems when oats were harvested for hay with the flail harvester. When the material was cut and put directly in windrows for drying, using the attachment shown in Figure 2d, the material on the bottom side of the windrow did not dry. The windrows formed by the harvester required turning one and two times before the hay would dry to storage level.

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APPENDIX I

Mean Moisture Content of the Second Cutting of Buffalo Alfalfa Hay Under Different Conditioning Treatments at Knoxville, Tennessee

Date and time of day	Percent moisture* (Wet basis) Check %	Crimped %	Smooth steel rolled %	Rubber rolled %	Flailed %	Temperature °F	Relative humidity %	Wind velocity mph	Cloud cover %
June 15, 1959									
4:45 p.m.	70.6	62.2	58.8	63.1	67.8	84.0	37.5	0-5	2
6:00 p.m.	66.5	55.5	54.9	54.8	59.8	82.0	38.5	0-2	0
June 16, 1959									
9:00 a.m.	65.2	53.7	50.4	50.6	54.4	79.0	70.0	0	1
10:00 a.m.	60.7	45.8	43.4	41.1	45.3	80.0	42.0	0	1
11.00 a.m.	52.9	39.4	36.1	34.0	37.1	81.5	38.0	0-3	2
12:00 noon	46.5	28.3	30.9	25.3	33.4	84.0	29.0	6-8	0
1:00 p.m.	43.7	24.1	26.1	19.9	26.8	87.0	25.0	5-10	0
2:00 p.m.	40.6	19.6	21.0	22.4	23.9	87.0	25.0	0	0
Moisture content of uncut hay:						74.4 per cent			
Time of mowing and conditioning with									
smooth steel roller crushers:						2:45 p.m., June 15, 1959			
crimping roller						3:15 p.m., June 15, 1959			
rubber roller crusher						3:45 p.m., June 15, 1959			
Time of mowing of check:						4:00 p.m., June 15, 1959			

*These data are an average of four different plots.

APPENDIX II

Mean Moisture Content of Soybean Hay Under Different Treatments at Knoxville, Tennessee

Date and time of day	Percent moisture (Wet basis) Check %	Crimper %	Crusher %	Temperature °F	Relative humidity %
August 26, 1958					
4:00 p.m.	73.8	66.6	66.3	84.0	47
6:00 p.m.	67.8	54.5	61.0	78.0	55
August 27, 1958					
10:00 a.m.	60.9	47.0	61.2	75.0	63
12:00 noon	56.4	38.3	48.2	83.5	47
2:00 p.m.	55.8	27.9	36.5	85.0	43
4:00 p.m.	54.2	13.6	25.7	85.0	38
August 28, 1958					
4:00 p.m.	39.9	8.75	10.4	86.5	33
Cutting time:			2:00 p.m., August 26, 1958		
Moisture content at cutting time:			77.6 per cent		
Wind speed:			0-2 mph (every day)		
Cloud cover:			scattered cumulus clouds (every day)		

APPENDIX III

Mean Moisture Content of Oat Hay Under Different Conditioning Treatments at Knoxville, Tennessee

Date and time of day	Percent moisture (Wet basis) Check %	Conditioned %	Temperature °F	Relative humidity %	Wind velocity mph	Cloud cover %
May 31, 1960						
1:20 p.m.	64.2	62.6	79	44	0-5	20
2:30 p.m.	56.9	61.8	79	44	0-2	20
3:15 p.m.	57.4	46.8	80	41	2-6	20
4:00 p.m.	55.5	45.2	79	43	0-5	20
5:00 p.m.	54.2	47.1	78	45.5	0-2	10
6:00 p.m.	54.4	40.4	77	45	2-5	2
June 1, 1960						
10:00 a.m.	51.5	35.3	77	52	6	0
2:15 p.m.	35.8	21.7	85.5	34	2	0
3:15 p.m.	37.0	19.4	84	39	3	0
4:15 p.m.	36.0	19.3	81	41	0	0
6:45 p.m.	36.4	——	76	55	0	Haze
Moisture content of uncut hay:				70.3 per cent		
Time of mowing of check:				11:15 a.m.		
Time of mowing and conditioning treatment:				11:00 a.m.		

APPENDIX IV

Mean Moisture Content of Alfalfa Hay Under Delayed Conditioning Treatments ot Knoxville, Tennessee

Date and Time of Day	Percent moisture (Wet basis) Check %	No delay %	10 min. delay %	24 min. delay %	39 min. delay %	56 min. delay %	Temp. °F.	Relative Humidity %	Wind vel. m.p.h.	Cloud cover	%
9/14/60											
1:30 p.m.	62.23	61.05	60.06	61.46	64.77	62.90	74.5	49	0-3	Haze	50%
3:30 p.m.	52.02	43.78	43.23	49.86	50.82	52.01	71.5	54.5	5-7	Haze	90%
5:30 p.m.	48.95	39.86	38.97	41.24	47.12	46.30	67.0	73	0	Haze	100%
9/15/60											
10:10 a.m.	50.88	41.63	41.25	43.89	44.79	47.28	71	64	6	Haze	20%
12:10 p.m.	42.31	30.66	27.78	31.61	32.26	37.67	76	51	3	Haze	75%
2:10 p.m.	34.69	18.46	19.17	22.29	22.33	24.33	78	57.5	0-2	Haze	80%
4:10 p.m.	32.15	17.29	16.96	20.52	20.16	23.88	77	56	0-2	Haze	90%
		Moisture content of uncut hay:							76.33		

Time of cutting of treatments:

Check treatment mowed @ 11:00 a.m. — Not conditioned

No delay treatment mowed @ 11:16 a.m. — conditioned @ 11:16

10 minute delay treatment mowed @ 11:16, conditioned @ 11:26

24 minute delay treatment mowed @ 11:16, conditioned @ 11:40

39 minute delay treatment mowed @ 11:16, conditioned @ 11:55

56 minute delay treatment mowed @ 11:16, conditioned @ 12:12

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