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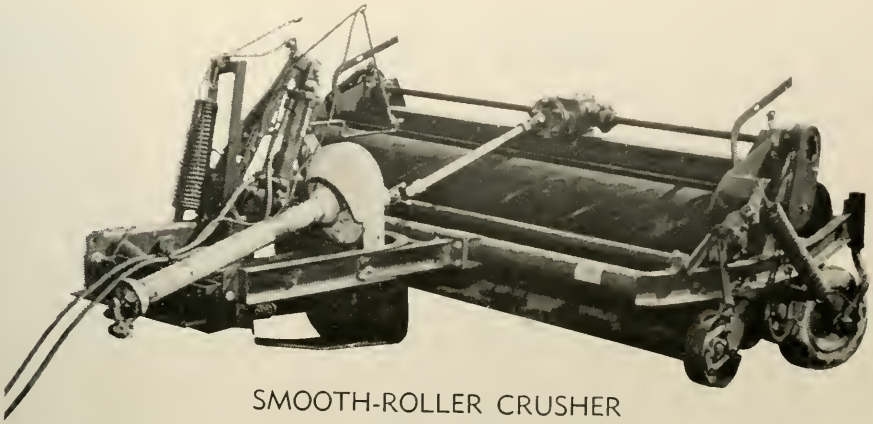

SMOOTH-ROLLER CRUSHER

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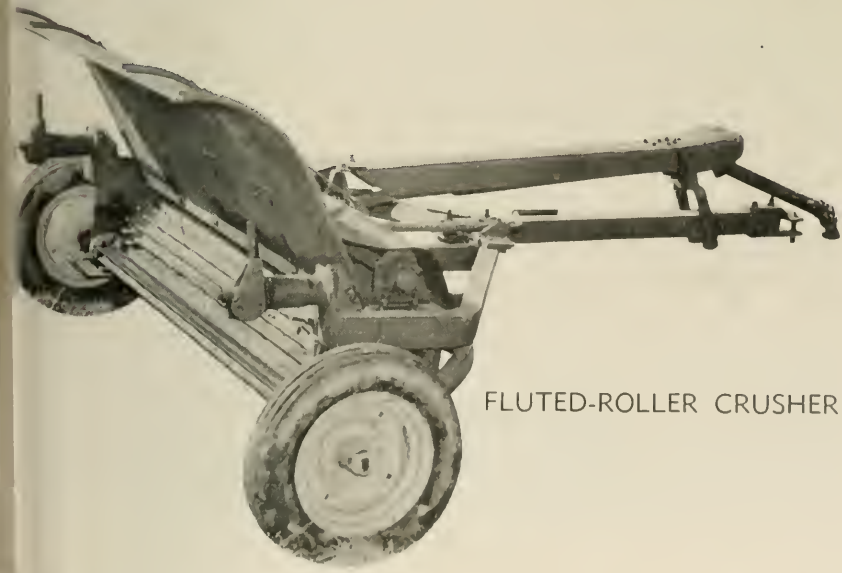

FLUTED-ROLLER CRUSHER

ST VIRGINIA UNIVERSITY AGRICULTURAL EXPERIMENT STATION

THE AUTHORS

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Performance of Forage Crushers

P. JOHN ZACHARIAH, K. C. ELLIOTT, and R. A. PHILLIPS

DRYING of forage in the swath with minimum spoilage and deterioration in quality is a problem which faces farmers. To dry hay to 20 per cent moisture may require leaving the forage in the field for two to four days, depending upon the nature of the forage and weather.

Unfavorable weather during the forage harvesting season causes large quantities of forage to spoil or deteriorate in quality. In West Virginia, more than half of the annual precipitation occurs between April and September. The frequency of rain during the forage harvesting season increases the risk of spoilage. The reduction in quality is due to leaching of the nutrients, the bleaching action of the sun, and leaf shattering due to extra handling. Weather forecasts usually help the farmer to avoid spoilage. However, many farmers, in their anxiety to complete hay harvesting and to avoid overmaturing and deterioration in the quality of forage, are tempted to continue their operations regardless of unfavorable weather forecasts.

Any process or operation which would reduce the period the forage has to be cured in the field is of importance to the farmer. The harvesting of partially cured forage from the field and removal of moisture in excess of the safe storage level by forced air is a common practice. This involves extra work and additional expense.

In legumes, 30 to 40 per cent of the weight is in the leaves. The leaves dry at a much faster rate than the stems during conventional field curing. When curing hay to approximately 20 per cent moisture, the leaves become bleached, dry, and brittle before the stems are dry. Excessive drying of the leaves increases shattering during subsequent operations and results in reduced quality of the hay.

Considerable progress has been made during the last few years in developing forage crushers which speed the field drying rate of forages. These crushers crack the stems. This operation exposes more surface for moisture loss.

Commercial forage crushers may be divided into two general groups the smooth roller (Figure 1, cover) and the fluted roller (Figure 2, cover). The smooth-roller crusher will be referred to as a roll crusher and the fluted-roller crusher as a crimper. The roll-crushing unit of the tower-crusher consists of two, 1-foot diameter steel rollers 6¾ feet long.

A slatted pick-up cylinder in front of the roller feeds the hay between the rollers. The shaft of one of the rollers is spring loaded so that crushing pressures can be varied as crop conditions change. The mower and crushing units are so arranged that the forage is crushed during the following round.

The crimper has two fluted rollers which interlock and cover a 6-foot swath. One of the rollers is driven by the power received from the tractor power-take-off shaft, and the other rotates by contact with the driven roller. The forward motion of the crimper and the rotation of rollers pick up the forage.

The crushing action of the two types of crushers is slightly different. The stems are crushed uniformly throughout their length by a smooth roller machine; whereas the crimper machine cracks the stems at 1- to 2-inch intervals. The increased rate of moisture removal in the latter case is accomplished by moisture traveling along the lengths of the unbroken stem to these ruptures.

Experimental Procedures

To determine the performance and efficiency of the two types of crushers and their effect on different crops, the following experimental procedures were used.

Plots approximately 50 feet long and wide enough to contain 14 to 15 swaths were selected (Figure 3). The plots were uniform in crop

FIGURE 3. Gathering forage samples for moisture determinations.

intensity and slope. The crop was mowed after the dew had evaporated. The mowed crop, except for two swaths, was crushed with one or the other of the two types of machines. Each swath was roll-crushed or crimped at different pressures. Swaths given different treatments after mowing lay side by side, and for all practical purposes had uniform drying conditions. The moisture content of the forage was determined at the time of mowing. The rate of drying of crushed forage was determined by collecting samples in cloth bags at 1- to 3-hour intervals during the drying period. Samples were weighed immediately after they were taken from the field and again after oven drying for 2-½ days at a temperature of 155° to 160° F.

Two methods were used for collecting samples. One consisted of collecting forage from an area large enough to make up a sample of 2 to 3 pounds. Removal of all forage within a frame 4 feet long and 2 feet wide constituted the second method. The latter method had the advantage that the quantity per acre and the effect of bunching on drying rate could be determined from the weights of the samples collected inside the frame. Relative humidity, temperature, wind conditions, and soil moisture to a depth of 1 to 3 inches were periodically recorded.

In the following discussion, the moisture content of various crops subjected to different treatments are given. The graphs and tables were prepared from individual tests and are indicated by the day on which the data were collected. To determine the effect of one single factor, whenever conditions were favorable, the tests were repeated several times.

Effect of Roll Crushing and Crimping on the Field Drying Rate

The purpose of crushing, whether by smooth or fluted roller, is to speed up the field drying of forage. Cracking of the stems speeded drying. Leaves have a high rate of drying when compared with stems. Even when the leaves become dry and brittle the stems contain a high percentage of moisture. Crushed stems dry nearly as fast as leaves. Moisture determinations of soybean leaves and stems treated differently and field cured over the same period of time are shown in Table 1.

The beneficial effects of crushing were more pronounced in legume crops than in grass crops. Soybeans, red clover, and alfalfa have thick stems compared with grass. Hence, when these crops were crushed, the stems were uniformly cracked. Results show that during average drying weather, forage of 65 to 70 per cent initial moisture mowed and crushed in the morning dried to 18 to 25 per cent moisture by late afternoon. However, if the initial moisture content of the crop was

Table 1. Moisture in Stems and Leaves of Soybeans

Treatment	Per Cent Moisture	
	Stems	Leaves
At the time of cutting	70	74
After field curing		
Trial I Crushed	42	33
Trial I Crimped	43	31
Trial I None (Mowed Only)	54	29
Trial II Crushed	32	21
Trial II Crimped	29	19
Trial II None (Mowed Only)	46	20

more than 75 per cent, and if the yield was more than 10 tons per acre (wet basis), the forage had to be left in the field over night. Table 2 and Figures 4, 5, 6, and 7 show the field drying rate of uncrushed (mowed only), crimped, and roll-crushed red clover, clover-timothy mixture, timothy, and soybeans. The data in Table 2 indicate that in good drying weather, crushed timothy and clover-timothy mixture will dry to 25 per cent moisture or less in 7 to 9 hours.

When moisture content in crushed timothy, timothy-clover, and brome grass forages reached approximately 25 per cent, moisture in uncrushed forage cured over the same period was about 33 to 40 per cent. In soybeans, red clover, and alfalfa the difference ranged from 15 to 25

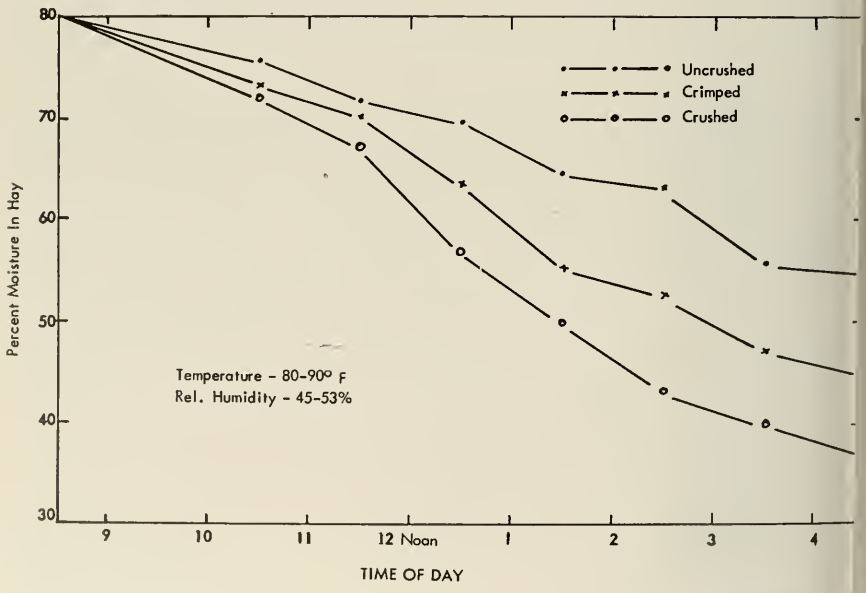


FIGURE 4. Effect of crimping and crushing on the drying rate of red clover

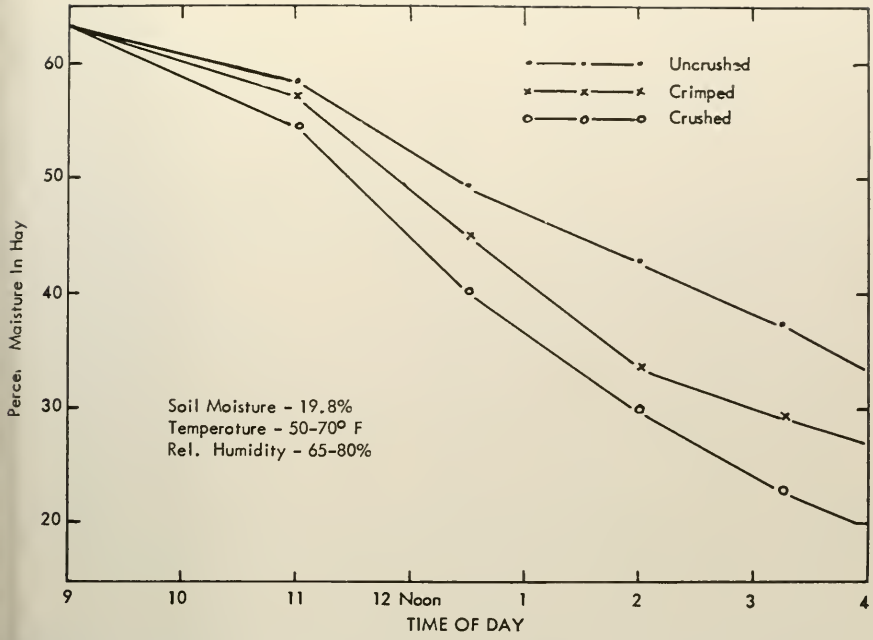


FIGURE 5. Field drying rate of uncrushed, crimped, and crushed clover-timothy mixture.

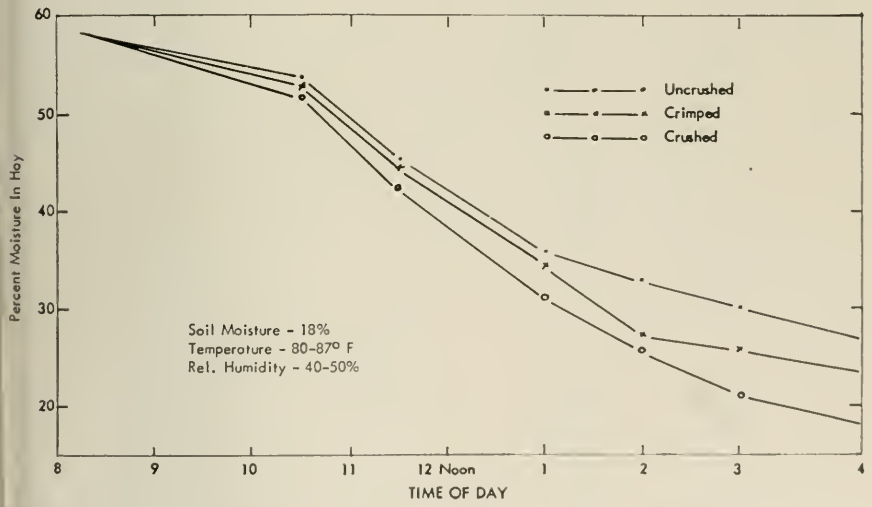


FIGURE 6. Field drying rate of uncrushed, crimped, and crushed timothy.

per cent. Most of the tests showed that smooth-roller crushing is more effective than crimping. However, there was no appreciable difference in the drying rate of crimped or crushed soybeans (Figure 7).

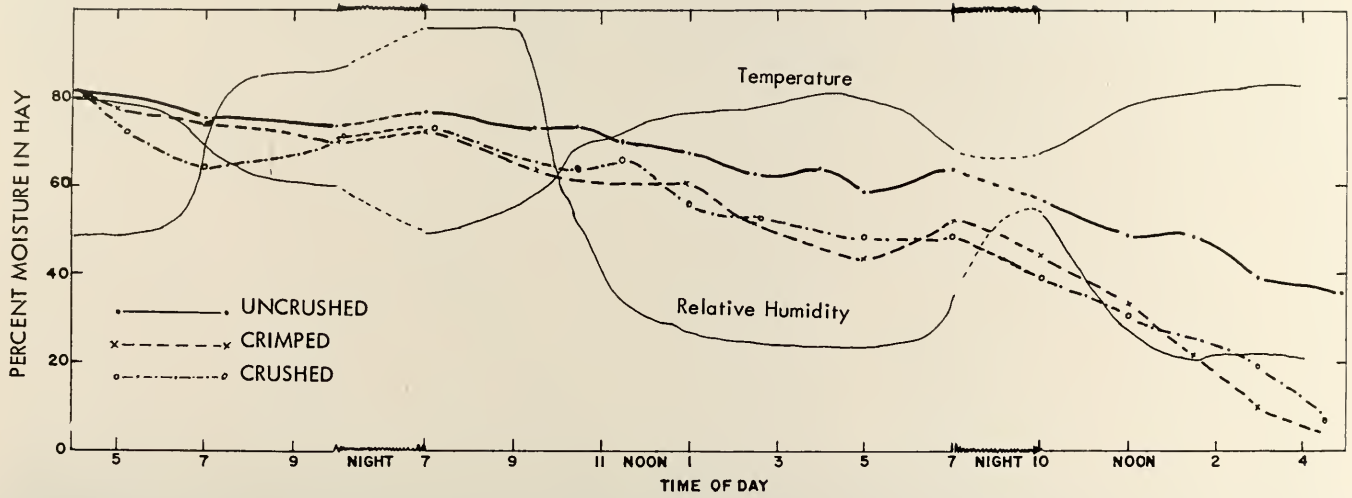


FIGURE 7. Drying rates of uncrushed, crimped, and crushed soybeans.

Table 2. Field Drying Rates of Mowed, Crimped, and Crushed Hay

Time Cut	Temperature °F	Relative Humidity %	Per Cent Moisture		Time Samples Taken	Per Cent Moisture Treatment After Mowing		
			Forage	Soil		None	Crimped	Crushed
June 18, 1957 Clover-Timothy 8:15 A.M.	85-90	60-70	75.5	**	11:00 A.M.	61.7	58.8	53.0
					2:15 P.M.	42.2	30.0	22.0
					5:20 P.M.	28.8	18.0	15.9
July 2, 1957 Clover-Timothy 9:00 A.M.	50-70	65-80	62.9	18.8	11:00 A.M.	58.2	57.3	54.5
					12:30 P.M.	49.3	45.0	40.0
					2:00 P.M.	43.0	33.5	30.0
					3:15 P.M.	37.4	29.5	23.0
					4:00 P.M.	33.8	27.0	20.0
July 3, 1957 Timothy 8:15 A.M.	80-87	40-50	58.0	16.6	10:30 A.M.	54.1	53.0	52.0
					11:30 A.M.	45.6	45.0	42.5
					1:00 P.M.	35.5	34.0	31.0
					2:00 P.M.	33.2	27.0	26.0
					3:00 P.M.	30.5	26.0	21.0
					4:15 P.M.	27.3	23.0	17.5
July 12, 1957 Clover 2nd Cut 8:30 A.M.	80-90	45-53	80.0	20.4	10:30 A.M.	75.4	73.0	72.0
					11:30 A.M.	71.5	70.0	67.0
					12:30 P.M.	69.4	63.5	57.0
					1:30 P.M.	64.6	55.0	50.0
					2:30 P.M.	63.0	53.0	43.0
					3:30 P.M.	55.7	47.0	40.0
					4:30 P.M.	54.5	45.0	37.0

**Data not available.

Preliminary tests were made to determine the drying rate of baled hay which was crushed and uncrushed and dried by the heated forced air. The indications were that crushed hay dried faster than uncrushed.

Effect of Roll Crushing and Crimping Pressures on Drying Rate

The effect of roll crushing and crimping pressure on the rate of moisture loss and the optimum roller pressure for different crops was determined by crushing or crimping forage at various pressures. An increase in crushing pressure (Figures 8, 9, and 10) tended to increase the drying rate. The effect of increasing roller tensions on drying rate was more pronounced in red clover and alfalfa than in timothy and brome. As timothy stems are easily crushed, increasing the roller tensions beyond a certain value did not have any appreciable effect on the drying rate (Table 3-A). The clover-timothy mixture and pure red clover crushed at a higher pressure dried faster than those crushed at lower pressures (Table 3-B). During the various tests the minimum and maximum crushing pressures used were 13 and 40 pounds per inch length of roller. Crushing pressure of 13 lbs. per inch length tended to crush only the big stems, with negligible bruising of leaves, whereas a crushing pressure of 40 lbs. per inch length of roller gave uniform crushing, but 40 to 60 per cent of the leaves were bruised.

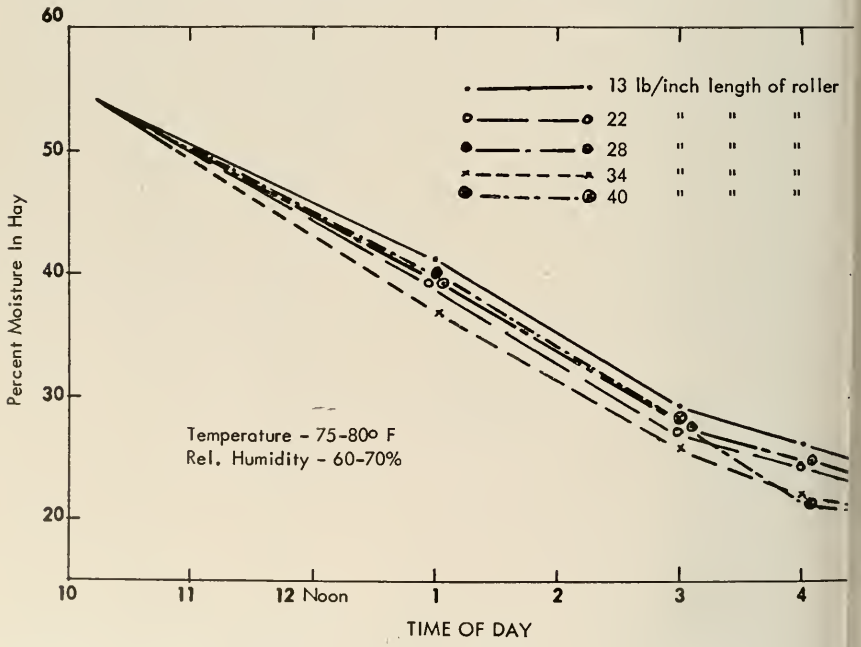


FIGURE 8. Effect of different crushing pressures on the field drying rate timothy.

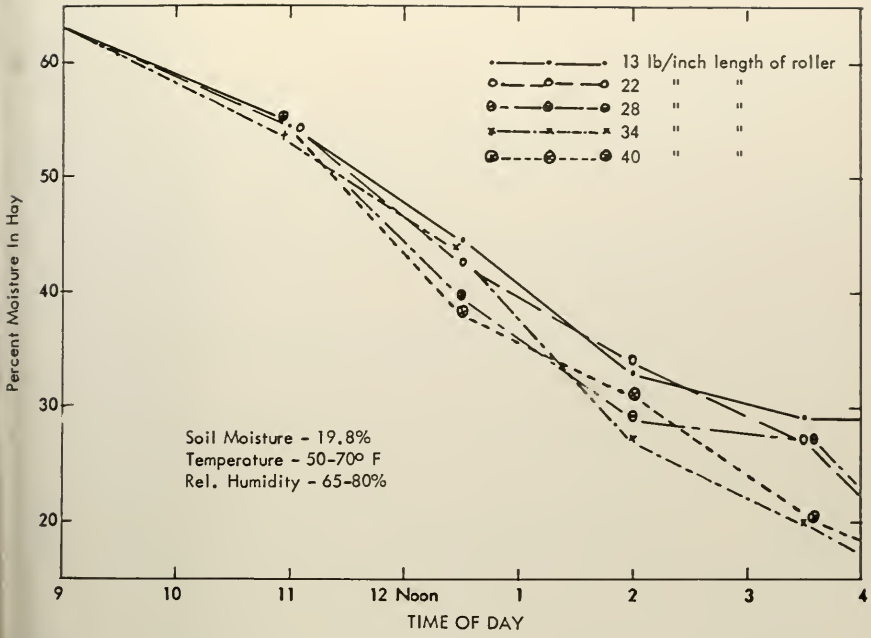
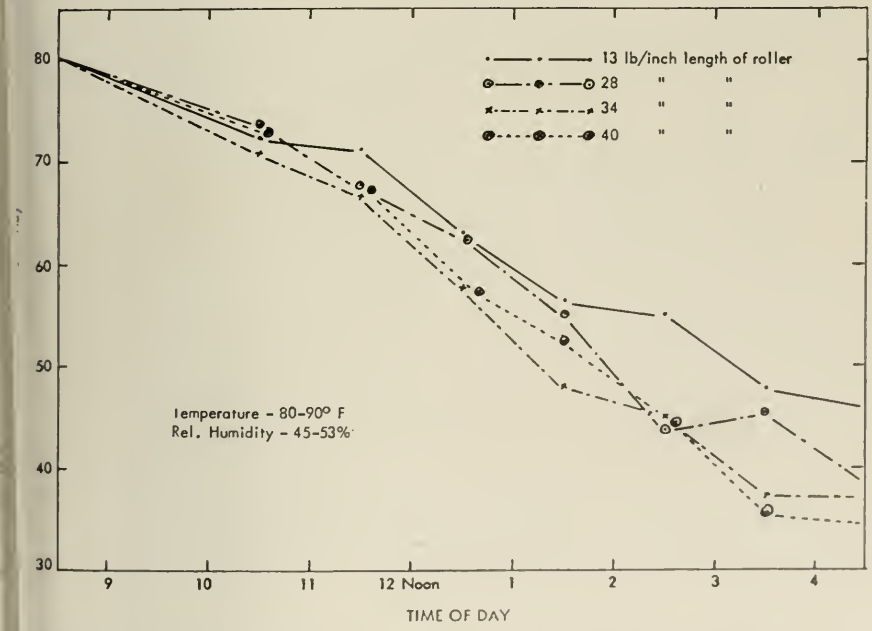


FIGURE 9. Effect of crushing pressures on the field drying rate of clover-timothy mixture.



IGURE 10. Effect of crushing pressures on the drying rate of red clover.

TABLE 3-A. EFFECT OF SMOOTH-ROLL CRUSHING PRESSURE ON THE DRYING RATE OF TIMOTHY AND BROME

DATE	TIME CROP WAS MOWED AND CRUSHED	PER CENT MOISTURE AT TIME OF CUTTING	TIME OF DAY SAMPLES TAKEN	PER CENT MOISTURE OF DIFFERENTLY TREATED FORAGE CRUSHED AT ROLL PRESSURES OF:					
				MOWED ONLY	LB/INCH LENGTH OF ROLL				
					13	22	28	34	40
June 10, 1957	1:00 P.M.	62.1	2:30 P.M.	57.0	45.7	50.2	43.0	48.0	53.4
			3:50 P.M.	48.9	38.1	36.6	38.0	37.0	35.3
			5:30 P.M.	39.6	33.4	28.5	25.8	22.8	25.8
June 17, 1957	9:15 A.M.	63.2	11:45 A.M.	43.2	40.0	40.2	34.6	38.2	34.8
			2:15 P.M.	27.3	23.2	25.2	17.7	19.1	19.7
			4:15 P.M.	22.0	16.8	15.5	15.2	10.5	11.7
July 1, 1957	10:15 A.M.	54.2	1:00 P.M.	41.2	41.1	39.4	38.9	36.4	39.4
			3:00 P.M.	36.4	29.4	28.9	27.5	25.3	28.4
			4:00 P.M.	34.7	26.3	24.4	24.9	22.2	21.4
July 2, 1957			10:30 A.M.	28.5	22.7	20.6	*	19.5	20.4
			1:00 P.M.	23.4	15.1	12.9	14.4	13.7	13.4
July 3, 1957	8:15 A.M.	58.0	10:30 A.M.	54.1	*	53.2	51.4	52.0	52.8
			11:30 A.M.	45.6	41.5	42.1	42.5	41.2	43.9
			1:00 P.M.	35.5	33.3	31.0	30.9	26.6	33.3
			2:00 P.M.	33.2	26.6	29.0	*	26.0	24.0
			3:00 P.M.	30.5	25.5	28.6	*	22.1	19.5
			4:45 P.M.	27.3	18.2	19.6	17.9	15.6	14.6

*Data not available.

Table 3-B. Effect of Smooth-Roll Crushing Pressure on the Drying Rate of Clover and a Clover-Timothy Mixture

Date	Time Crop Was Mowed and Crushed	Per cent Moisture at Time of Cutting	Time of Day Samples Taken	Per cent Moisture of Differently Treated Forage Crushed at Roll Pressures of:					
				Mowed Only	lb/inch length of roll				
					13	22	28	34	40
July 2, 1957	9:00 A.M.	62.9	11:00 A.M.	58.2	54.6	54.0	*	54.2	55.8
			12:30 P.M.	49.3	44.6	42.5	39.8	44.0	37.6
			2:00 P.M.	43.0	32.8	39.3	29.4	27.3	31.6
			3:15 P.M.	37.4	28.8	27.0	27.7	20.1	20.3
			4:00 P.M.	33.8	30.4	21.9	21.4	17.0	18.7
July 12, 1957	8:15 A.M.	80.0	10:30 A.M.	75.4	72.1	66.2	73.6	70.6	72.7
			11:30 A.M.	71.5	71.2	66.4	67.9	66.6	67.0
			12:30 P.M.	69.4	62.9	57.7	63.0	55.5	57.2
			1:30 P.M.	64.6	56.1	48.5	54.9	48.0	52.8
			2:30 P.M.	63.0	55.0	44.1	43.7	44.9	41.6
			3:30 P.M.	55.7	47.6	42.2	46.8	37.4	35.5
			4:30 P.M.	54.5	46.5	38.5	38.2	37.7	*

*Data not available

The optimum smooth roll crushing pressures for different crops of 4 to 8 tons per acre are:

Timothy and brome	23 to 28 lb/in., length of roller
Clover-timothy mixture	25 to 30 lb/in., length of roller
Alfalfa, red clover, and soybeans	28 to 33 lb/in., length of roller

These pressures are recommended from results of the tests. Increasing or decreasing crimping pressures had negligible effect on the rate of drying.

Effect of Fluffing on Drying Rate

The unpacked condition in which forage is left on the field and the air circulation through it appeared to affect the drying rate.

The crimper was modified to obtain maximum possible fluffing (Figure 11). The smooth-roll crusher had a fluffing shield as an integral part. Forage that was conditioned by another crimper, having no noticeable fluffing action, was used to serve as a basis of comparison between fluffed and unfluffed forage. Atmospheric conditions were anticipated to have considerable influence on the effect of fluffing. Observations made of the atmospheric relative humidity, and humidity below the forage and close to the soil as well as temperatures of atmosphere, temperature on top and under the forage are given in Tables 4-A and 4-B. These observations were made during the field drying rate tests conducted on alfalfa and soybeans. Table 4-A shows that during the drying period the relative humidity of air below the forage is higher than that

FIGURE 11. Crimper with modified (adjustable) deflector to obtain maximun fluffing.

Day and Time	Sky Condition	Moisture in Hay (Alfalfa) %	Relative Humidity %		Temperature °F		
			Atmospheric	On Soil Surface and Below Forage	Atmospheric	On Top of Forage	On Soil Surface and Below Forage
7th August							
11:00 A.M.	Bright	66	57	66	*	*	*
12:00 A.M.	Bright	62	53	68	81	90	81
12:00 P.M.	Bright	57	50	70	85	106	80
1:45 P.M.	Cloudy	45	51	70	80	85	80
3:00 P.M.	Bright	37	48	58	80	85	80
4:00 P.M.	Cloudy	33	43	62	85	86	76
5:00 P.M.	Bright	30	47	69	87	90	73
8th August							
7:30 A.M.	Cloudy	52	96	95	55	55	61
8:30 A.M.	Cloudy	*	83	82	72	69	68
9:30 A.M.		35	63	89	72	78	69
10:30 A.M.	Slight Overcast	24	45	76	84	88	76
11:30 A.M.	Bright	*	42	61	90	102	72
12:00 A.M.	Cloudy	21	40	44	88	89	76

*Data not available.

Table 4-B. Temperature and Relative Humidity in the Vicinity of Soybeans During Field Drying

Day and Time	Sky Condition	Air Movement	Moisture in Hay (Soybeans) %	Relative Humidity %		Temperature °F		
				Atmospheric	On Soil Surface and Below Forage	Atmospheric	On Top of Forage	On Soil Surface and Below Forage
Sept. 5, 1957								
7:00 A.M.	Foggy	Still	68	97	97	52	52	54
9:30 A.M.	Foggy	Still	65	96	94	56	60	59
10:30 A.M.	Bright	Slight Breeze	62	70	62	50	72	68
11:30 A.M.	Bright	"	57	39	72	69	71	66
1:00 P.M.	Bright	"	54	29	72	72	83	42
2:00 P.M.	Bright	"	51	27	73	75	92	72
2:30 P.M.	Bright	"	48	24	75	77	96	72
3:30 P.M.	Bright	"	46	23	42	79	91	73
5:00 P.M.	Bright	"	44	23	55	83	84	70

FIGURE 12. Good fluffing (left swath) no fluffing (right swath, mowed only)

of the atmosphere. Good fluffing (Figure 12) facilitates replacement o the humid air from the forage with less humid atmospheric air an penetration of the sun's rays. Thus it promotes more uniform dryin through the entire thickness of the forage. Data in the tables als show that the air temperature at the top surface of the forage is highe than that of atmospheric temperature, the difference reaching as muc as 21° F.

Results of fluffing, given in Table 5, show that there was negligibl difference between the moisture of fluffed and unfluffed timothy drie over the same period, while beneficial effects from fluffing were obtaine in the clover-timothy mixture (Figure 13). During wilting the narrow, lon leaves of timothy and of other grass crops curl. Thus there is les resistance to air movement and the penetration of the suns rays tha in broad-leaved legumes. Crushed legumes may lie in an unpacked con dition, yet the leaves form a layer on the surface. Visual observation indicate that timothy lays unfluffed when crushed with the crimpe having the conventional shield. The nature of timothy permits sufficien aeration and nearly uniform drying through the entire thickness o forage in the swath. There was no difference in the rate of drying be tween the fluffed and unfluffed timothy.

The rate of moisture transfer within the stems is relatively slow An increase in aeration above a certain level does not speed up drying

TABLE 5. EFFECT OF FLUTED ROLLER PRESSURE AND FLUFFING ON THE DRYING RATE OF CRUSHED HAY

DATE AND CROP	TIME MOWED	MOISTURE CONTENT %	TIME SAMPLES TAKEN	PER CENT MOISTURE					
				CRIMPED			CRIMPED AND FLUFFED		
				LOW CRIMPING PRESSURE	MEDIUM CRIMPING PRESSURE	HIGH CRIMPING PRESSURE	LOW CRIMPING PRESSURE	MEDIUM CRIMPING PRESSURE	HIGH CRIMPING PRESSURE
June 27, 1957 Timothy	8:45 A.M.	57.4	10:45 A.M.	47.0	*	43.0	40.5	40.0	38.3
June 28, 1957			1:15 P.M.	27.6	29.7	27.1	24.6	24.7	30.4
			3:30 P.M.	24.2	20.2	18.5	20.9	22.0	19.2
			9:00 A.M.	26.1	25.6	25.3	25.4	25.7	23.8
			12:00 Noon	18.0	15.8	15.6	20.7	16.6	14.6
July 1, 1957 Timothy	10:15 A.M.	54.2	1:00 P.M.	42.5	42.3	42.0	40.2	41.5	43.2
July 2, 1957			3:00 P.M.	33.8	33.0	32.4	33.0	31.6	33.2
			4:00 P.M.	30.3	28.4	29.0	30.0	27.9	26.8
			10:30 A.M.	24.1	23.4	23.3	24.6	23.3	25.2
			1:00 P.M.	17.4	15.2	16.6	17.0	15.3	13.6
July 3, 1957 Timothy	8:15 A.M.	58.6	10:30 A.M.	52.0	54.6	52.1	54.8	52.0	48.8
			11:30 A.M.	44.7	46.0	44.6	47.5	44.6	44.4
			1:00 P.M.	35.7	34.3	32.0	41.5	39.6	33.8
			2:00 P.M.	27.2	27.2	*	*	28.8	27.6
			3:00 P.M.	26.7	25.7	25.8	29.4	24.7	23.6
			4:15 P.M	22.6	25.8	26.1	20.5	*	*
July 2, 1957 Red Clover-Timothy Mixture	9:00 A.M.	62.9	11:00 A.M.	57.8	58.2	56.3	56.2	53.5	56.0
			12:30 P.M.	43.9	47.7	44.3	43.2	39.6	46.0
			2:00 P.M.	30.0	34.2	35.8	36.8	33.7	36.2
			3:15 P.M.	33.8	27.7	27.4	28.1	33.5	30.0
			1:00 P.M.	28.9	26.1	25.6	24.5	24.8	20.0
July 12, 1957 Red Clover 2nd Cut	8:15 A.M.	80.0	10:30 A.M.	74.5	73.6	72.0			
			11:30 A.M.	72.6	70.9	69.6			
			12:30 P.M.	63.8	64.7	63.0			
			1:30 P.M.	57.1	57.7	54.4			

*Data not available.

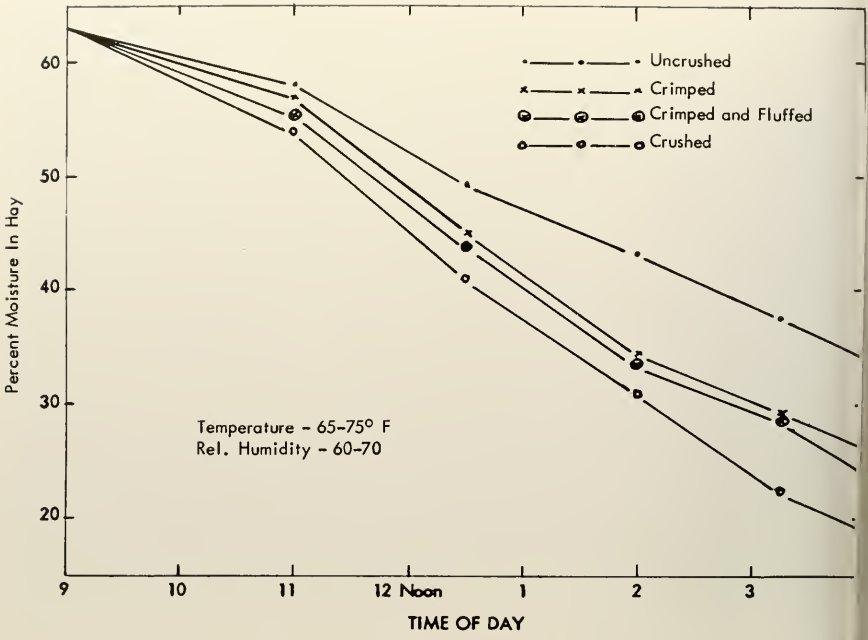


FIGURE 13. Effect of fluffing on the field drying rate of clover-timothy mixture

When most of the tests were conducted, the soil moisture was less tha 21 per cent and there was a slight breeze throughout the drying perio To obtain conclusive results on the effect of fluffing, additional tes with crops of different yields per acre growing in fields of different so moisture, and an accurate recording of wind movement during th entire drying period would be necessary.

Adjustment of the shield (Figure 11) to obtain good fluffing legumes is very important. Poor adjustment of the shield would cau too little fluffing or bunching. This would reduce the drying rat Hence, for any particular crop, the adjustment of the shield for goo fluffing action should be made during a few initial runs and checke periodically.

Power Requirements of the Two Types of Crushers

Laboratory tests of the smooth-roll crusher at different roller te sions gave a requirement of 3.0 to 4.7 horsepower while running empt Field testing for power used by the smooth-roll crusher and crimper w conducted while crushing alfalfa and soybeans. Measurements we made by a power-take-off dynamometer,* designed and constructed

*P. John Zachariah, *A PTO Torsion Dynamometer*, Bulletin in print, West Virgi University Agricultural Experiment Station, Morgantown, West Virginia.

FIGURE 14. PTO dynamometer measuring power requirements of crusher.

he Agricultural Engineering Department of the University (Figure 14). Test results in Table 6 show that the roll crusher at various roller pressures used 7.0 to 10.8 horsepower. During the power tests the pick up cylinders were adjusted so that they were well above the ground but low enough to pick up all the forage. The crimper required less than 1 horsepower.

Considering only power requirements, both the crimper and mower-crusher can be operated by a 2-plow tractor. The mower-crusher combination weighed approximately 1,000 pounds at the hitch point to the tractor. Though the power requirement of the mower-crusher is within the capacity of a 2-plow tractor, a 3-plow tractor is required for easy maneuverability.

TABLE 6. POWER REQUIRED TO CRUSH ALFALFA*
(SMOOTH-ROLL CRUSHER)

ROLLER TENSION IN LBS.	LBS./INCH ROLL LENGTH	POWER-TAKE-OFF SHAFT SPEED	PTO HORSEPOWER
1882	13.0	530-550	7.0
2024	22.3	530-550	7.2
2568	28.2	530-550	8.8
3112	31.2	530-550	9.4
3656	40.1	530-550	10.8

*3.65 tons/acre with 71 per cent moisture.

General Observations

The roll crusher and crimper used for the tests had very good pick up abilities. Both types worked best when crushing was done shortly after mowing. While crushing alfalfa and red clover, an occasional build-up on the smooth crusher roller was noticed. This was very thin, and since it peeled off periodically, it did not create any problem or decrease the proper functioning of the rollers. Wrappage on the crimper rollers was observed while crushing timothy and red clover. On most occasions, such wrappages occurred at the ends of swaths when the power-take-off speed was reduced before stopping the forward motion of the tractor. The reduced roller speed did not throw the forage an adequate distance to prevent it from recycling so that the hay wrapped on the rollers.

When the mowing was done at a low ground speed, the forage was laid on the ground non-uniformly with some of it crosswise to the swath. Forage that fell crosswise to the swath would lay bunched after it was crushed. This bunching slowed the drying rate.

With crusher roller tensions of over 30 pounds per inch length of roller, 30 to 50 per cent of the leaves of alfalfa and red clover were bruised. This caused the leaves to dry faster than the stems.

Often the moisture content of forage will increase during the night. The drying rate and moisture absorption of differently treated timothy is given in Figure 15. The curve shows that on the average, moisture absorbed during the night was not lost until 10 A.M.

Quality of Crushed Hay

Work done by other Experiment Stations show that the quality of crushed hay is better than uncrushed. Crushing accelerated the field drying rate. Hence, crushed forage is less exposed to weather hazards. Leaves contain more than 50 per cent of the total digestible nutrients in most legumes. More nearly uniform drying of stems and leaves reduces the loss of leaves by shattering during raking and baling operations. Carotene content in crushed hay at the time of baling and after five months storage was reported to be 30 to 50 per cent higher than uncrushed hay which was field cured to the same moisture level. Crushing of the thick and woody stems makes the hay more palatable.

Summary

Crushing speeds up field drying of hay. Grass crops respond to crushing to a lesser degree than thick-stemmed plants. Most of the crop with less than 75 per cent initial moisture, when mowed and crushed in the morning, will dry to 20 to 25 per cent moisture the same evening if drying conditions are favorable.

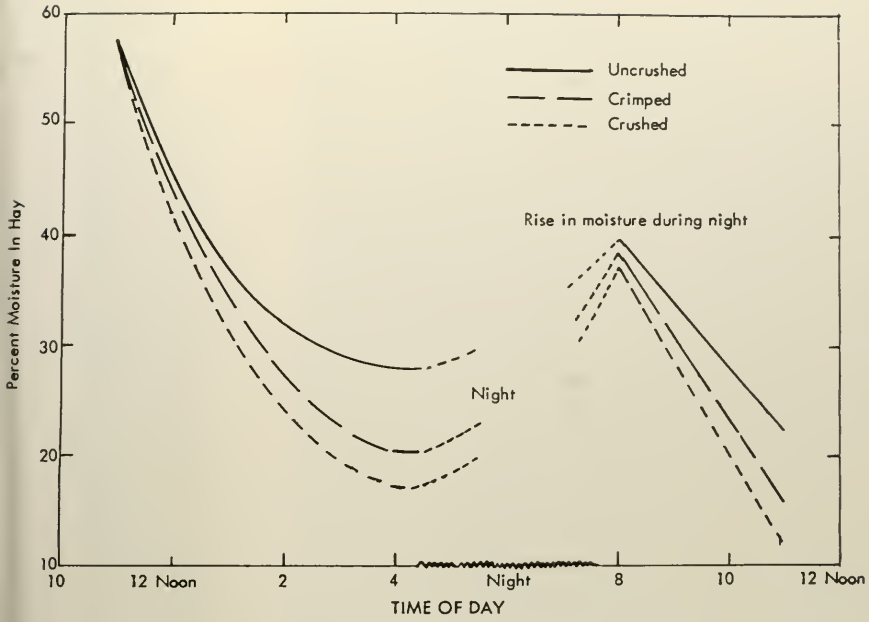


FIGURE 15. Field drying rate and absorption of uncrushed, crimped, and crushed timothy.

Soybeans and red clover have a lower drying rate than grass crops. These and other legume crops with yields exceeding 8 tons per acre (wet basis) took more than a day to reach 20 to 25 per cent moisture. In general, smooth-roller crushing was found to be more effective than crimping. On very thick-stemmed crops such as soybeans smooth-roller crushing and crimping have an equal effect.

The power requirements of the crusher and crimper are within the capacity of a 2-plow tractor. However, the weight and handling characteristics of the smooth-roll crusher-mower combination requires a 3-plow tractor for satisfactory operation. Since mowing and crushing can be combined into one operation, crushing requires very little additional expense for labor. Reduced chances of spoilage or deterioration of the quality of forage by unfavorable weather and reduction in nutrient losses caused by exposure to weather over lengthy periods are the major factors in favor of hay crushers.