MECHANICALLY TREATING HAY FOR MOISTURE REMOVAL

by

P. J. Kurtz
Member C.S.A.E.
Conestoga College of Applied Arts and Technology
Kitchener, Ontario

W. K. Bilanski
Member C.S.A.E.
School of Agricultural Engineering
University of Guelph, Guelph, Ontario

INTRODUCTION

The loss of feed value, in weather-damaged hay, can vary from 25 to 40 per cent (9), and is a major concern to forage producers. It is desirable that hay be stored as quickly as possible after cutting to minimize losses and preserve quality.

Numerous research programs performed over the past years have revealed that mechanical treatment of the hay increased the drying rate over the untreated material. Geographic location also tended to have a bearing for some mechanical treatments on their hay drying rates. A review of the published literature revealed that crushing (2, 3, 5, 6, 7, 8, 10) and crimping (6, 7) of the hay increased the drying rate over untreated hay, with the former treatment removing moisture quicker than the latter (1). Swathed material dried faster than windrowed material of the same treatment (5). Geographic location appeared to have an effect on the flail mower treatment as Boyd (1) and Hall (4) found hay with this treatment dried quicker than crushed hay and Halyk (5) and Kurtz (8) found the opposite to occur.

Modern forage harvesting machines were employed in this study in an attempt to accelerate the field drying of hay. An evaluation was made of their relative effectiveness in removing moisture without the assistance of artificial drying equipment. Four widely separated test locations within the hay growing area of the province were utilized. Alfalfa hay was selected in three of the four test areas.

PROCEDURE

Four treatments were replicated four times in a randomized complete block design. The experiment was performed in field plots in Ridgetown, Guelph, Kemptville and New Liskeard areas. The mechanical treatments, with the machines used to produce them, are identified in table 1.

The newest models of the machines available in Ontario were used for the experiment. The sample plots were made the same size in order to ensure that the material density of each windrow would be similar. The largest flail mower available made a seven foot cut, consequently, all plots were trimmed to seven foot widths. All cut hay was placed in windrows of identical widths to properly compare the effects of the treatments on drying.

With the exception of the self-propelled windrower, all equipment was powered by the tractor p.t.o. Machine adjustments were made to produce the maximum theoretical benefits, using the manufacturers' recommendations when available. The ground speed of the machines was set at four miles per hour with the tractor engine speed adjusted to operate p.t.o. equipment at the A.S.A.E. standard of 540 rpm.

The test area, which was approximately 2 acres in size, was divided into four blocks with each section being split into four plots seven feet wide.

TABLE I. THE 1966 MACHINE TREATMENTS ON FIRST CUT HAY

Treatment No.	Machines	Treatments
1	Flail Mower (FL)	Cutting, conditioning and windrowing
2 (Figure 1)	Self-propelled windrower (S P W)	Cutting, windrowing and and crushing
3 (Figure 2)	Multi-treatment machine (M T M)	Cutting, crushing and windrowing
4	Cutter-bar mower and crusher conditioner (M-C)	Mowing followed by a separate crushing and leaving in a windrow

Testing was done only on first cut hay with the alfalfa in a late bud-early bloom stage. The hay had an average yield of one and one-half tons per acre.

The hay was cut and treated between 7:00 a.m. and 8:00 a.m., after any overnight dew had evaporated. To obtain the expected maximum drying advantage for the separate crushing treatment (treatment No. 4 in table 1), this operation followed cutting within a time limit of 15 minutes. All other treatments were developed by one-operation machines. The order in which the treatments were undertaken was randomized within each of the four blocks.

Samples of the cut forage for moisture determination were taken from one of the four blocks from each of the four treated plots at three-hour

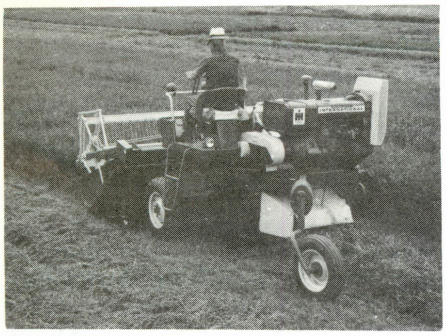

Figure 1. The McCormick International 201 Self-Propelled Windrower

Figure 2. The Multi - Treatment Machine. New Holland 460 Haybine.

intervals during the day and at four-hour intervals during the night. These were collected from each of the four replications of each treatment at the beginning of the project and at the end of the afternoons of the first and second days after cutting. Sampling was discontinued when it was felt that the hay reached a 25 per cent moisture content or had dried for two days. The hay samples were sealed in polyethylene bags and stored at 35°F until moisture determinations could be made. The A.O.A.C.* two hour oven method was employed in determining the moisture contents.

RESULTS AND EVALUATIONS

The data from this experiment, which were in the form of moisture contents for each treatment at each location, were examined in two ways:

1. Hay sampling at three or four hour intervals enabled graphs of moisture content versus drying time to be plotted which permitted the comparison of the drying curves for the various treatments.

2. Elimination of the original water density variation across each field when sampling began, was performed by using an analysis of covariance so the treatment could be properly evaluated. For selected time intervals the water losses for each treatment were compared.

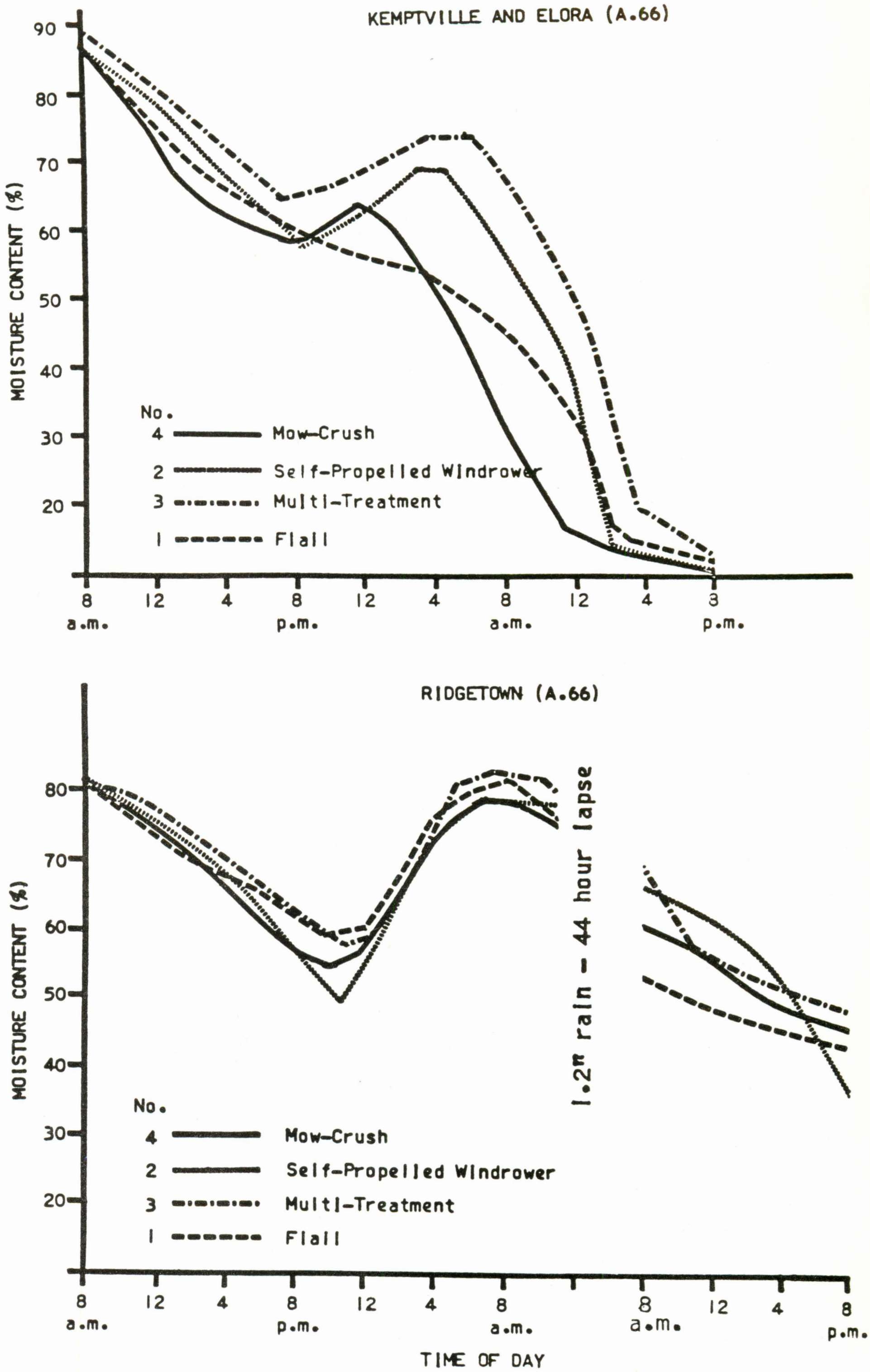

Figure 3. Drying Curves For Treated Alfalfa Hay.

1. Drying Curves

Drying curves were plotted from the data of all four experimental locations. The Ridgetown, Elora and Kemptville test centers had predominantly alfalfa hay while the New Liskeard hay was a brome, timothy, alfalfa mixture. The drying rates of each treatment at Elora and Kemptville were similar, consequently, a composite curve for each treatment was drawn (figure 3). Rain fell at Ridgetown and New Liskeard during

*Association of Official Agricultural Chemists.

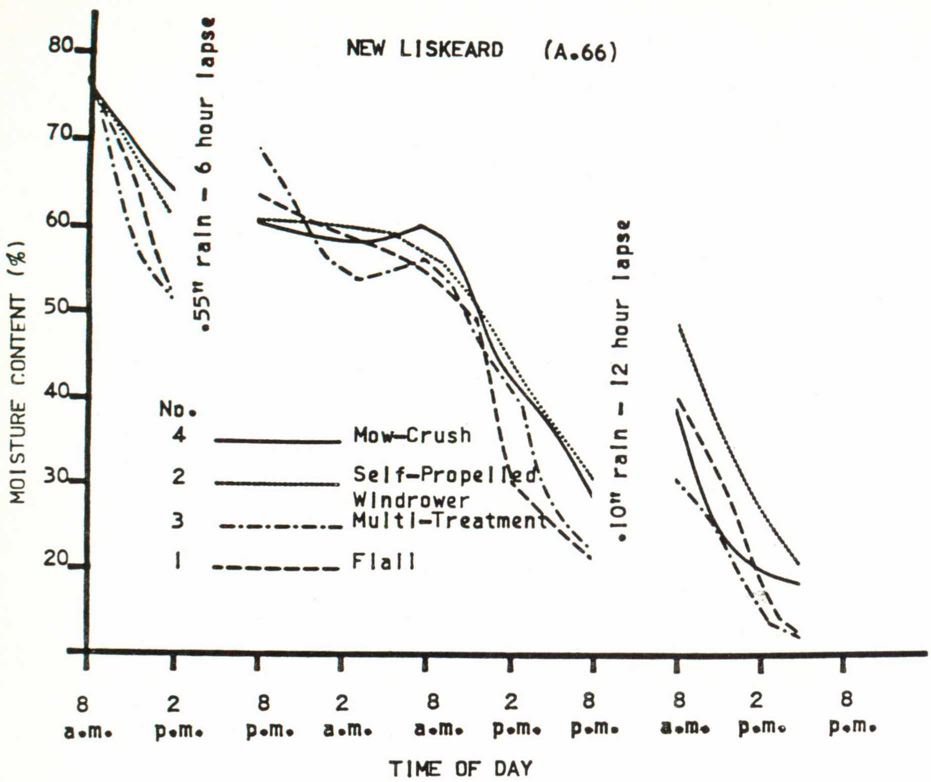

Figure 4. Drying Curves For Treated Mixed Hay.

the sampling period, after which the sampling for moisture content was continued. The resulting curves for Ridgetown (figure 3) and New Liskeard (figure 4) were constructed.

Overnight moisture regain caused diurnal fluctuations in moisture content which are obvious in all of the curves. The intertwining of the curves of the treatments being compared illustrated the varied responses to climatic conditions and emphasized the difficulty associated with the analysis of the data.

The two separate operations of mowing and crushing appeared to give the best moisture removal rate in the test areas that yielded predominantly alfalfa hay (figure 3) where no rain occurred. The forage cut with the multi-treatment machine seemed to take on a very high overnight moisture regain which, when added to quite a high first day moisture content, possessed the slowest drying rate. The hay cut with the self-propelled windrower dried as rapidly as the mow-crush treatment the first day but with a large overnight regain lost its initial drying advantage. The significant factor in the flail treated hay was the very little overnight moisture regain with a gradual almost constant drying best drying characteristics followed curve throughout the test period.

Moisture loss from forage in the Ridgetown area (figure 3) after the first day of drying was quite similar to the Elora and Kemptville areas, with possibly hay treated by the self-propelled windrower drying the most rapid. The rain had the least effect on the flailed material, while the hay treated by the self-propelled windrower and the multi-treatment machine showed a relatively large increase in moisture content. The self-propelled windrower treated forage appeared to develop a very high drying rate after the 60 per cent moisture content value had passed.

The material from the multi-treatment machine and the flail mower dried the quickest before it rained on the mixed hay at New Liskeard (figure 4).

After the first rainfall and a full 24 hour drying interval the flailed mower produced the hay with the best drying characteristics followed by the multi-treatment machine. Only the materials from the mow-crush and the multi-treatment machines indicated a rise in moisture content due to overnight regain in this period.

The second rainfall seemed to affect the drying rate of the forage from the multi-treatment machine the least and the self-propelled windrower the most.

2. *Covariance Analysis*

The effectiveness of the hay treatments at specified periods after cutting, was compared by a statistical analysis to establish if significant differences between the treatments existed. The variation in original water contents in the hay across the field was eliminated by the covariance analysis. For each treatment at each location the original ratio of water weight divided by dried matter weight was compared to the ratio calculated at the selected time intervals. Thus, the treatment producing the maximum moisture loss over the specified period was determined.

The results of the covariance analysis indicated, for all four experiment locations that a difference between the treatments did exist (95% confidence limits) but there was no difference between the four replications of each treatment at any particular location. Also, there was no significant difference between locations.

The adjusted treatment means, for the water weight to dried weight ratios, which are products of the covariance analysis, were combined for the alfalfa hay locations. Average means transcribed into percentages representing the ratios on the wet moisture basis at the end of the first, second and fourth days of drying appear in table 2. A relative comparison, using Duncan's New Multiple Range Test, was performed on the means. These means, with their corresponding times of selection for the New Liskeard hay samples, are presented in table 3.

The mow-crush treatment produced the best moisture removal which was significantly better than the moisture removal by the multi-treatment machine for alfalfa hay with no rain after one and two days of drying. Flailed material, after a rainfall, had the lowest moisture content which was significantly lower than the multi-treatment machine's material.

The forage from the multi-treatment and flail units appeared to dry significantly quicker than the forage from the self-propelled windrower or the mow-crush treatments in the mixed hay with no rain. With one day of drying after each of the two periods of precipitation, the flail and multi-treatment methods were still significantly better operations for accelerating the drying of this type of hay.

CONCLUSIONS

The quickest drying rate was demonstrated by the alfalfa hay which was treated by the mow-crush process. When the alfalfa was subjected to precipitation, the drying rate of the material from the flail mower was the least affected with the hay from the mow-crush treatment drying slightly slower.

The best drying characteristics in the mixed hay analysis were possessed by the forage treated with the multi-treatment machine, which combines mowing and crushing into one operation.

REFERENCES

1. Boyd, M. M. Hay Conditioning Methods Compared. Agricultural Engineering. 40, 664-667, 1959.
2. Bruhn, H. D. Status of Hay Crusher Development. Agricultural Engineering. 36, 165-170, 1955.
3. Bruhn, H. D. Performance of Forage-Conditioning Equipment. Agricultural Engineering. 40, 667-670, 1959.
4. Hall, G. E. Flail Conditioning of Alfalfa and Its Effect on Field Losses and Drying Rates. Transactions of A.S.A.E. 7, 435-438, 1964.
5. Halyk, R. M., and Bilanski, W. K. Effects of Machine Treatments on the Field Drying of Hay. Canadian Agricultural Engineering. 8, 28-30, 1966.
6. Kepner, R. A., Goss, J. R., Meyer, J. H., and Jones, L. G. Curing Rates, Field Losses and Feeding Response with Crimped, Rolled and Untreated Alfalfa Hay. Paper No. 59-132 presented at A.S.A.E. Annual Meeting at Cornell University, Ithaca, N.Y., June 1959. (Mimeographed.)
7. Kepner, R. A., Goss, J. R., Meyer, J. H., and Jones, L. G. Hay Conditioning Effect on Nutrient Content. Agricultural Engineering. 41, 229-304, 1960.
8. Kurtz, P. J., and Bilanski, W. K. Machine Treatments on Field Drying Hay. Canadian Agricultural Engineering. 9, 113-116, 1967.
9. Oliver, J. H. Quality Control in Hay Making. Agricultural Engineering. 41, 748-750 and 761, 1960.
10. Pederson, T. T., and Buchele, W. F. Drying Rate of Alfalfa Hay. Agricultural Engineering. 41, 86-89, 1960.

TABLE II. ADJUSTED MOISTURE CONTENT MEANS - ALFALFA HAY

Drying Period (hours)	Rain	Treatments* M-C	FL	SPW	MTM
o vs. 9	No	63.5**	65.5	66.0	70.0
o vs. 36	No	10.0	11.5	11.5	12.5
o vs. 81	Yes	49.0	48.0	50.0	53.0

TABLE III. ADJUSTED MOISTURE CONTENT MEANS - MIXED HAY

Drying Period (hours	Rain	Treatments* MTM	FL	SPW	M-C
o vs. 6	No	51.5**	52.5	61.5	64.5
o vs. 36	Yes	28.0	26.0	39.0	37.5
o vs. 57	Yes	11.5	11.5	19.3	17.4

* These abbreviations are outlined in Table 1.

** Per cent moisture on wet basis.