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Studies on the Effect of Conditioning Processes on the Field Drying Time of Forages

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Abstract

The effects of conditioning processes, underlying layer and weather factors on field drying rate of alfalfa were investigated. Drying of chopped, macerated and dewatered alfalfa was affected progressively by the intensity of the change in physical characteristics and inversely by the rate of moisture transfer from the underlying surface. The depressing effect on the drying rate of rolling the macerated and dewatered samples into sheets approximately 6mm thick, was more noticeable on a wetter underlying surface.

Introduction

The time required to field dry forages to a moisture content which is safe for baling is instinctively judged by most farmers rather than determined through any precise scientific prediction or measurement. Little is known about the specific drying time required for various forage crops under a wide variety or combination of weather conditions, changes in physical characteristics of the forage by various conditioning equipment, and wetness of the surface on which the forage is placed during field drying.

Experience of most farmers and studies (Hart and Burton, 1967; Bruck and Eldersen, 1969) have shown that the rate of field drying of agricultural materials depends primarily on weather conditons (as external factors) and the properties of the material to be dried (as internal factors).

It is assumed that in field drying of alfalfa forage, the important external factors are:

1. air temperature.
2. wind speed and direction with respect to swath or windrow,
3. air relative humidity,
4. field surface wetness, and
5. solar radiation.

The important internal parameters are:

1. amount of solar radiation (absorbed),
2. diffusion resistance of material to water loss which depends on moisture content and characteristics of material and
3. material temperature.

For proper prediction of drying time, it is necessary to know the separate effects of these parameters and alsc how they possibly interact. Henderson and Pabis (1961) have shown that the Arhenius equation is satisfactory in relating the rate of drying with temperature. The effect appears in the diffusion coefficient D_v in the equation.

$$D_v = D_o e^{-A/T} \quad \ldots\ldots \quad (1)$$

where D_o and A are constants

T = air temperature

Henderson and Perry (1966) reported that it can be conveniently assumed that material temperature is built into the above equation and that the drying process can be described without considering the temperature gradient in the material (Rowe and Gunkel, 1971).

Since the internal resistance to moisture movement in agricultural materials is so great compared to the surface mass transfer resistance, air flow rate past the particles has no significant effect on time of drying. Rowe and Gunkel (1971) have shown that air humidity enters the drying rate prediction equation in the value of equilibrum moisture content. Little is known about the effect of underlying layer but Paderson and Buchele (1960) have shown that placing a black or transparent polyethlene vapor barrier under the windrow of alfalfa increased the drying rate. It is expected that the wetter the underlying layer the slower the drying.

It has also been shown that moisture movement in the material is affected by material temperature, moisture content, vapor pressure in the material, and material density all of which vary during drying (Henderson and Pabis, 1961). However, except for large-size objects such as lumber, the assumption of constant diffusion does not introduce any appreciable error into the analysis of drying behaviour and prediction of drying time (Henderson and Perry, 1966).

Various conditioning procedures are known to reduce time of hay drying up to 30%. Priepke and Bruhn (1970) concluded that conditioning methds that increase the exposed surface area of the material have been shown to reduce drying time considerably.

This study was carried out to identity the effect of such conditioning processes as maceration, dewatering and rolling on the field drying rate of alfalfa. The effect of such external factors as underlying layer and weather parameters on the drying rate were also investigated.

Materials and Methods

The materials used in this study were chopped, macerated and dewatered alfalfa. Maceration of the alfalfa was done using a rotary extruder assembly with extrusion orifices drilled radially in the die ring. Dewatered alfalfa was first macerated and then further treated in a screw press to remove about half of the initial moisture. About 4.5 kg of material was put in a 1m by 1.3m rectangular tray fabricated of formed sheet metal and 6.3mm square mesh hardware cloth (Bruhn, 1959). White pieces of cotton cloth were placed on the netting to prevent the loss of fine material during drying. The forage was spread carefully and evenly on the tray to ensure that no spaces were left for direct passage of the sun's rays through the material mat. Thus, it could be assumed that all the radiation on the area of the tray was intercepted.

Duplicate 4.5 kg samples of each material (chopped, macerated, and dewatered alfalfa) were prepared. One sample was placed on a concrete slab and the other placed on a blue grass lawn as horizontally as possible on the east side of the Agricultural Engineering Laboratory of the University of Wisconsin, Madison, U.S.A. While actual conditions may vary from day to day, the concrete slab and the blue grass lawn approximate the extreme field conditions from the dry soil to hay stubble on moist soil. The weight of the materials being dried were noted at about 30 minute intervals using the chattillon Dynamometer scale with a range of 0 – 11.34kg and a precision of 0.0045 kg.

After every drying run, the materials were carefully collected in the marked white cloths and placed in the oven at 66°C for dry matter weight determination. Thirty-six to forty-eight hours were required to reach equilibrum in the oven. This was considered dry matter weight for all conditions. Information about the important weather parameter was obtained on an hourly basis for the drying days from the National Weather Bureau, Madison, Wisconsin, which is a few miles away from the site of the drying studies.

It was recognized that both macerated forage or macerated and dewatered material would be very difficult to recover if it were dropped and cured on hay stubble. Therefore, some macerated and dewatered materials were rolled into flat sheets approximately 6mm thick using a 38.63kg rubber coated roller., The rolled materials were then dried in the same manner as described earlier for the unrolled materials.

Another experiment was performed to determine the comparative drying rate of samples of equivalent dry matter weight of:

1. chopped material,
2. chopped and macerated material, and
3. chopped, macerated and rolled material.

The screen bottom drying pans were placed on a concrete slab.

Results and Discussion

Effects of Underlying Layer

The underlying layer did not affect the rate of drying of chopped alfalfa significantly (Fig. 1). The effect was however more noticeable in the macerated alfalfa (Fig. 2), and much more so in dewatered alfalfa (Fig. 3). In both cases, drying was faster on the concrete also

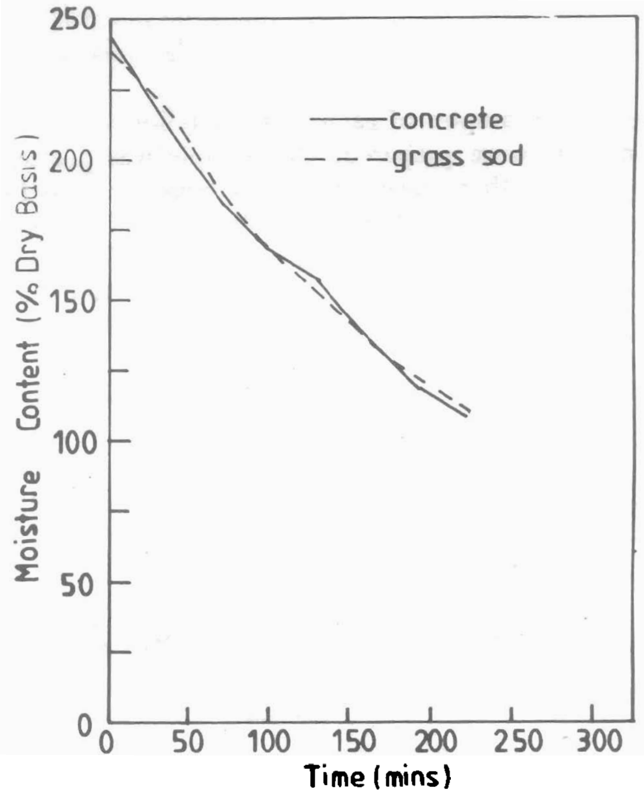

Fig. 1. Effect of underlying layer on drying rate of chopped Alfalfa.

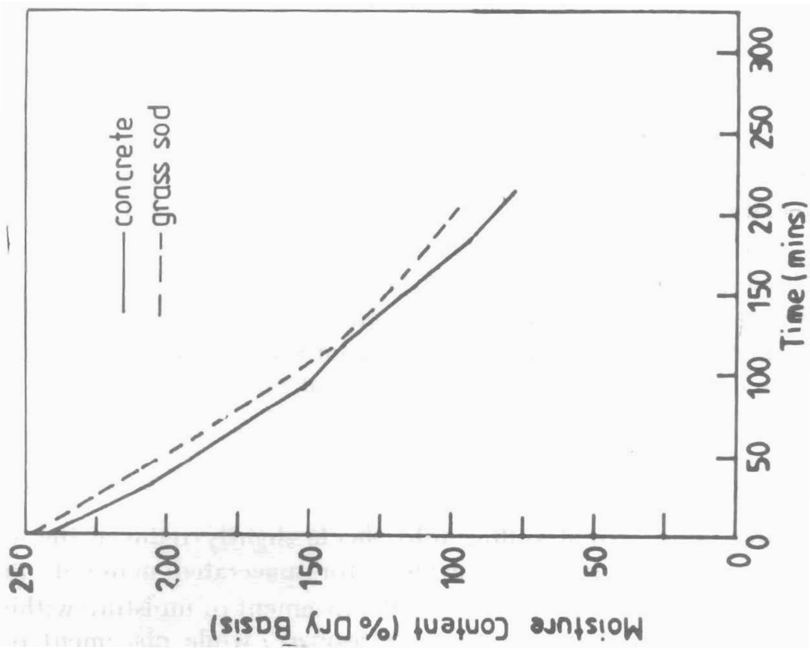

Fig. 2. Effect of underlying layer on drying rate of Macerated Alfalfa.

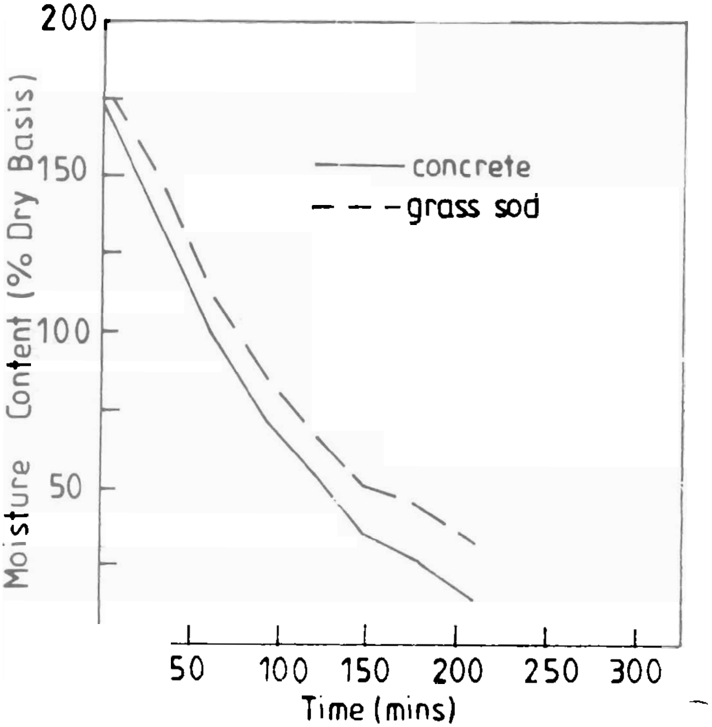

Fig. 3. Effect of underlying layer on drying rate of dewatered Alfalfa.

than on the blue grass sod. The macerated alfalfa attained a moisture content of about 85% dry basis within 200mins of drying on the concrete slab and 100% dry basis within the same period on the blue grass sod. The corresponding values for dewatered alfalfa were 20% on concrete slab and 40% on blue grass sod. The underlying layer affected drying rate more in the macerated material than in the chopped material probably because maceration increased the surface as well as the number and uniformity of voids. Therefore, the material conducted more water vapour from the subsurface of the material as drying progressed. Similarly, dewatering made the alfalfa drier and thus, more water could be absorbed from the subsurface due to transpiration of the underlying growing grass sod.

Effects of Rolling

Figure 4 shows that rolling into sheets slightly reduced the drying rate, the effect being more evident for macerated materials placed on grass (Fig. 5),. Rolling retarded movement of moisture within the material and its escape to the atmosphere, while placement of the rolled materials on grass ensured contact with a wet sublayer, from which additional water could be absorbed. This led to a lower drying rate. Rolling, for the same reasons, also slowed down the drying of the dewatered alfalfa.

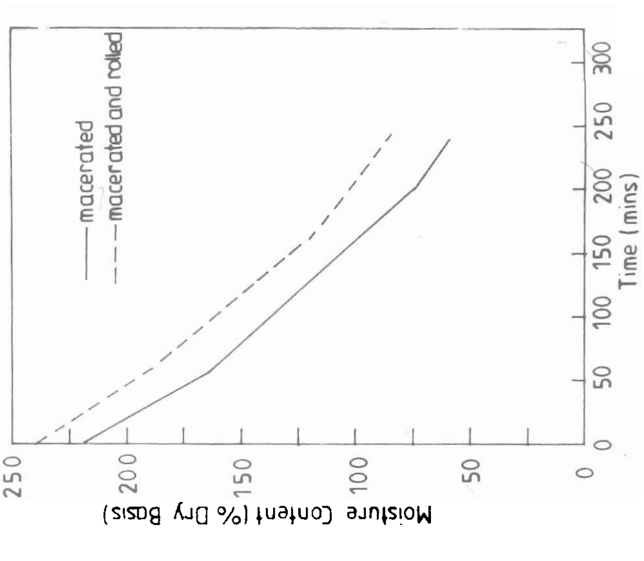

Fig. 4 Effect of rolling on drying of Macerated Alfalfa on concrete.

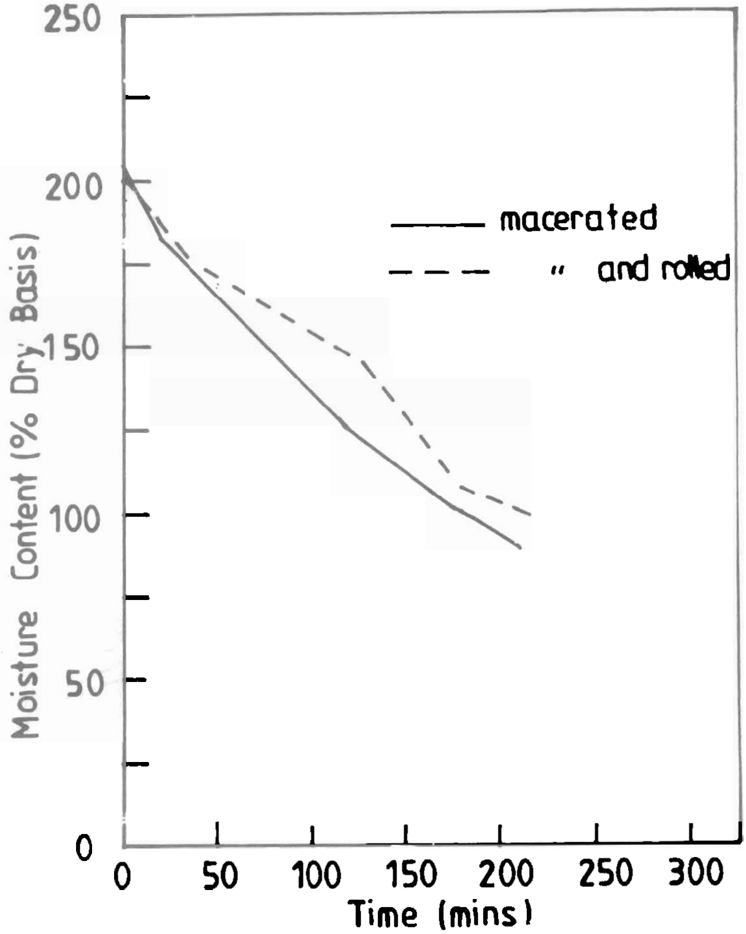

Fig. 5: Effect of rolling on drying rate of macerated Alfalfa placed on Grass sod.

Figure 6 shows that for the same amount of material of chopped, macerated and macerated and rolled alfalfa, the macerated material dried fastest, followed by the chopped material while the macerated and rolled material dried most slowly. This shows that the advantage of maceration is more than neutralized by rolling.

Figures 7 and 8 indicate that maceration accelerated the field drying of alfalfa. This is believed to be due to the fact that maceration increased the surface area, increases the number and uniformity of voids, and therefore increases the rate of diffusion of water vapor. Figures 7 and 8 also indicate that the dewatered material dried faster than the chopped material and about as fast as the macerated material.

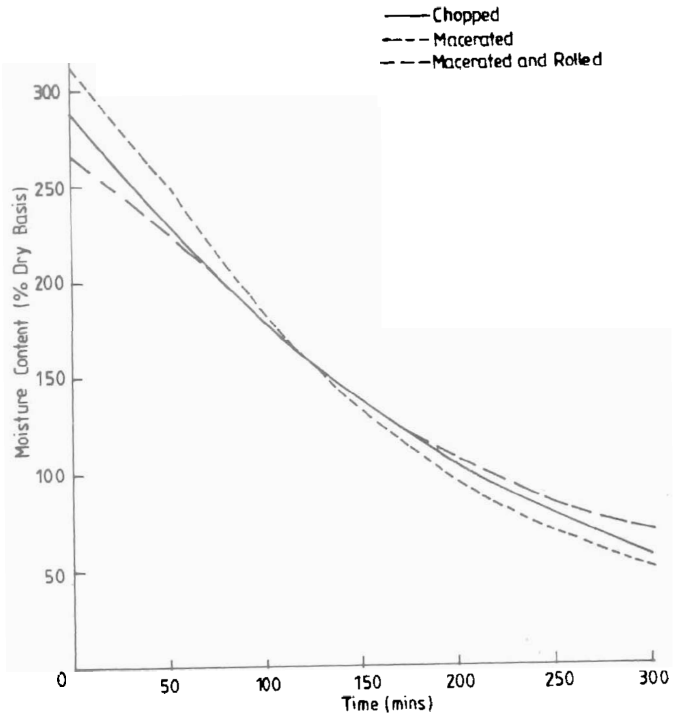

Fig. 6: Effect of Maceration and Maceration and Rolling on drying rate of Alfalfa.

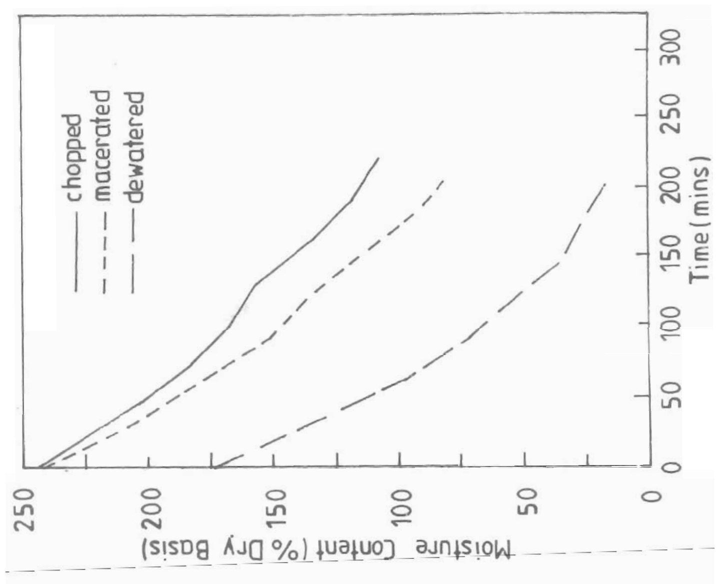

Fig. 7 :Effect of Maceration and Dewatering on drying rate of alfalfa placed

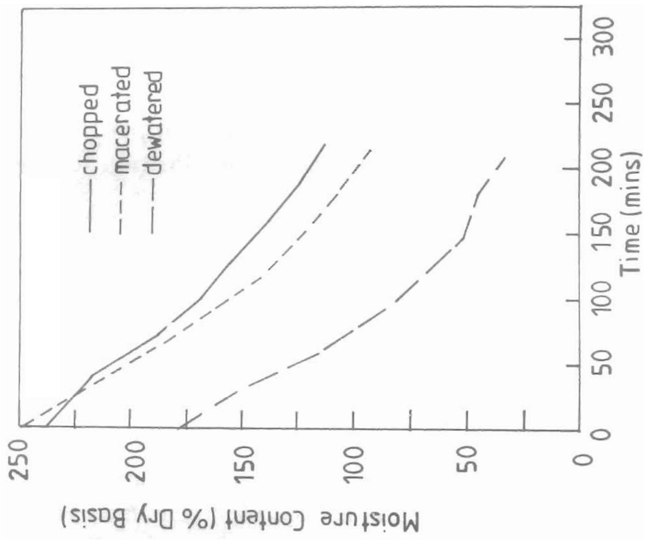

Fig. 8: Effect of maceration on drying rate of alfalfa placed on Grass sod.

Effect of Weather Factors

The relative effects of the various weather factors on the drying rate of the various material could not be evaluated comprehensively because of the inadequacy of the weather data. Nonetheless, from the results of experiments performed on concrete slab, it was observed that the dewatered material seemed to respond more to changes in relative humidity than the chopped or macerated material. Also, changes in air temperature seemed to play a greater role in drying rate determination of the chopped alfalfa than it did for the dewatered material. These will need to be studied further.

Conclusions

From the results of the experiments, it can be concluded that:

(1) The wetter the underlying layer, the slower the field drying rate of all the materials. This effect was most obvious for the dewatered alfalfa and least obvious for the chopped alfalfa.

(2) Rolling into sheets of approximately 6mm thickness reduced field drying rate of both macerated and the dewatered alfalfa. The macerated and rolled material dried some-what more slowly than the chopped material.

(3) Maceration increased the field drying rate of alfalfa and the total field drying time to a given moisutre content was greatly reduced by dewatering.

Acknowledgements

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