CONTROLLING MOLD IN ALFALFA BALED WITH CANADAS BALE VENTILATOR

Don A. Toenjes

Abstract: A 2' diameter, 11" long prong was mounted on the plunger face of a two-wire New Holland baler to create a 7/8" ventilator duct through the center of alfalfa bales put up with stem moisture and compared to baled without a vent. After 37 days, six temperature monitored field stacked bales varying in moisture from 20% to 32% were opened and examined for visual signs of mold and other conditions. Ventilated bales had 42 out of 45 slices mold free. Conventional bales had 7 out of 44 bale slices mold free. All bales had a strong tobacco odor. Interior temperature measurements indicated that the ventilating duct did affect the internal temperatures. Peripheral temperatures of the bales were also affected. The ventilating duct had little influence on peak bale temperatures. Changes in chemical components did appear to be related to time rather than treatment.

Keywords: Mold prevention in baled alfalfa, Sweat, Stack curing, Tobaccoing

INTRODUCTION

Field observations of summer stacks of alfalfa hay baled with relatively high moisture levels (20-30%), show that molds develop to the greatest extent in the interior of the bale or where the bale interfaces with another surface, be that another bale or the ground. From this observation a question arises: is this phenomenon dependent on restricted aeration? Would the creation of an air vent through the center of the bale:

Reduce or eliminate the formation of molds in the interior of the bale?
2. Would the vent influence the interior and peripheral temperature of the bale?
3. Would ventilation assist the bale to release moisture to the outside environment?
4. Are peripheral vented bale temperatures different than those created in the interior of the field stacked conventional bale?

Roy Canadas of Orland, California, a sheepman and hay grower, like many others had put up moldy hay that was largely wasted by his animals. However, some 10 or 12 years ago he posed the first question listed above. He wondered could he devise a device that would answer the first question? He set out to create a bale ventilator that would be mounted to the plunger of his two-wire balers. Some nine years ago he came up with a satisfactory answer that has helped him to sell the hay from his increased alfalfa acreage to neighboring dairymen. It wasn't easy. The ventilating probes mounted to the plungers of his two-wire balers were shaped and reshaped until they worked satisfactorily (Diagram 1).

Roy found that dairymen buyers seldom complained about palatability of his summer hay even when his yearly yields reached 10 tons per acre. He had found that the bale ventilator allowed him to put up alfalfa hay with a slightly higher moisture level. This created the environment for a "heavy sweat". The very slight tobacco odor in higher fiber summer hay causes it to be relished by cattle and sheep. Roy's success was noted by his neighbors.

The remainder of the questions listed above were mine. They came to mind when Roy decided to offer his idea to the industry and he requested help in setting up a demonstration project. I must admit I had some reservations about the slight tobaccoing that could occur. A search through the literature showed that the effects of browning or tobaccoing of alfalfa had been extensively investigated many years ago. However, most of us are unaware of the research findings.

In 1945 Betchel and Shaw reported that brown hay contained more ash and more crude fiber than hay from the same source cured normally. Excessive heating during storage resulted in decreased percentages of nitrogen-free extract and of ether extract (fat). Severe carotene (Vitamin A) losses were reported to be associated with losses of ether extract. Only the digestibility of the ether extract was found to increase with browning. All other constituents were found to drastically decrease. The brown hay studied was described as an extreme, ranging in color from light brown to dark brown.

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Browning and Van Soest in 1967 reported that they had examined the browning reaction and found it dependent on temperature and moisture. Alfalfa hay seemed susceptible at moisture levels above 20%. The rate of browning increased expotentially with temperature increases. Hemicellulose, a fiber fraction, appeared to be one of the major carbohydrate sources for browning.

Mohanty and Jorgensen in 1967 reported studies of the performance of steers that had been fed alfalfa hay that had reached 122°F. The steers were able to digest a higher portion of the fiber content of the brown hay than similar animals fed well-cured alfalfa from the same field and cutting. However, animal performance was somewhat less on the moldy hay. It could not be explained by the minor decrease in digestibility of the various fraction.

Miller and Clanton reported in 1967 that baling at higher levels of moisture resulted in higher levels of ash and crude fiber, but relatively unchanged the level of crude protein in the cured hay. They observed significant difference between levels of chemical constituents caused by varying the moisture (26.2%, 35.2%, 53.4% and 58.5%) level of isolated bales of mid-bloom alfalfa hay taken from the same field and cutting. The low moisture bales were described as green in color and no mold. Mold was observed to occur at an increased frequency as moisture levels increased. Internal temperature of the isolated bales were highly correlated with bale moisture level, with bale treatment averages peaking in temperature (degrees F) from a low moisture average of 112, 124, 144 to 148 for the highest moisture. There was no difference in the performance of 400 pound steers fed the two lowest moisture levels.

Nelson in 1968 studied the effects of various moisture levels in isolated bales. He reported that as moisture levels increased, baled hay cut at the bud stage of maturity had a higher proportional degree of loss of constituents than baled hay cut at half bloom or full bloom. It was also noted that peak temperatures were lower for the more mature alfalfa bales. He reported that 375 pound steers performed equally on alfalfa hay baled conventionally, and at 26% and 36% moisture.

These reports studied moistures that are higher than one might deem realistic under today's market demands. However, we proposed to study the vented two-wire bale at the same lower moisture levels used in some of the studies reported. We wanted to go to the outher limits of practical application under California climatic and hay market conditions. We would bale alfalfa with excessive stem moisture; monitor interior and peripherial temperatures of field stacked bales; observe changes in constituents; and observe the development of tobaccoing and mold within the bales.

THE STUDY

Roy selected a 200 acre dryland alfalfa field adjacent to the Sacramento River south and east of Hamilton City. Because of heavy dews and higher humidity, alfalfa hay took longer to cure at this location than inland fields. A two-wire baler that produced a 16x18x46-inch bale was used on May 28 to put up the vented and conventional bales, six high, in separate but adjoining field stacks, in a north-south orientation. Test bales were selected from the third layer from the ground on the west face of the stack according to their location in the layer (Table 1). Bales on the east face of layer three were sampled to obtain initial moisture levels, as were those bales on the west face, with a 3/8" probe. All sampling sites in the bales were plugged. Thermister probes, coupled to a CR 21 Data Logger, were inserted into the vent of the bale to the depth of 23". Holes 23" deep were created with the 3/8" hay probe for the insertion of the thermisters into the center of the conventional bales. These holes were also plugged. The CR 21 was programmed to measure temperatures in six bales every 60 seconds and to compute these into hourly averages. A soil probe thermometer, with an 8" shaft, was inserted near the end of the bales' top side, to measure peripheral temperatures.

The 37th day following baling, test bales were cored with a Penn State forage sampler and samples taken at this time were submitted for moisture and chemical analysis to compare with initial values. The vents of test bales at this time varied between 7/8 and 3/4" in diameter through the bale. Bales were broken and each slice was evaluated for development of mold.

RESULTS AND DISCUSSION

Internal temperature characteristics of the ventilated bales were obviously different from the conventional. Interior temperatures of ventilated bales fluctuated as much as 15°F in a 36-hour period (Graphs 1 and 2). The hourly variations within the bales did not respond immediately to changes in air temperature above the stack. Conventional bales assumed a steady upward or downward trend of temperatue changes. Location of the test bale within the stack appeared to influence the heat generating characteristics of the bales. Fastest temperature rise was observed in the bales located where the two stacks joined and slowest was observed in bales closer to either end of the stack. Peak temperatures were reached in the conventional bales as early as day 6 and as late as day 14 and minor peaks were observed. Vented bales peaked at days 9 and 10 but minor peaks were also observed later. Despite being somewhat lower on the average, temperature trends of the vented bales did not differ greatly from the conventional bales (Graph 3). Temperature levels measured at the exposed end of the bales did reflect their position within the stack, with the bales closest to the end of the stack being the coolest and the vented bales being several degrees cooler than the conventional bales (Table 1).

Moisture levels averaged 26.3% for the vented bales in layer three and 24.3% for the conventional bales at time of stacking. The test vented bales averaged 26.3% while the conventional bales averaged 28.2% moisture. Moisture levels dropped to 15% for the vented bales and 17.2% for the conventional bales (Table 1).

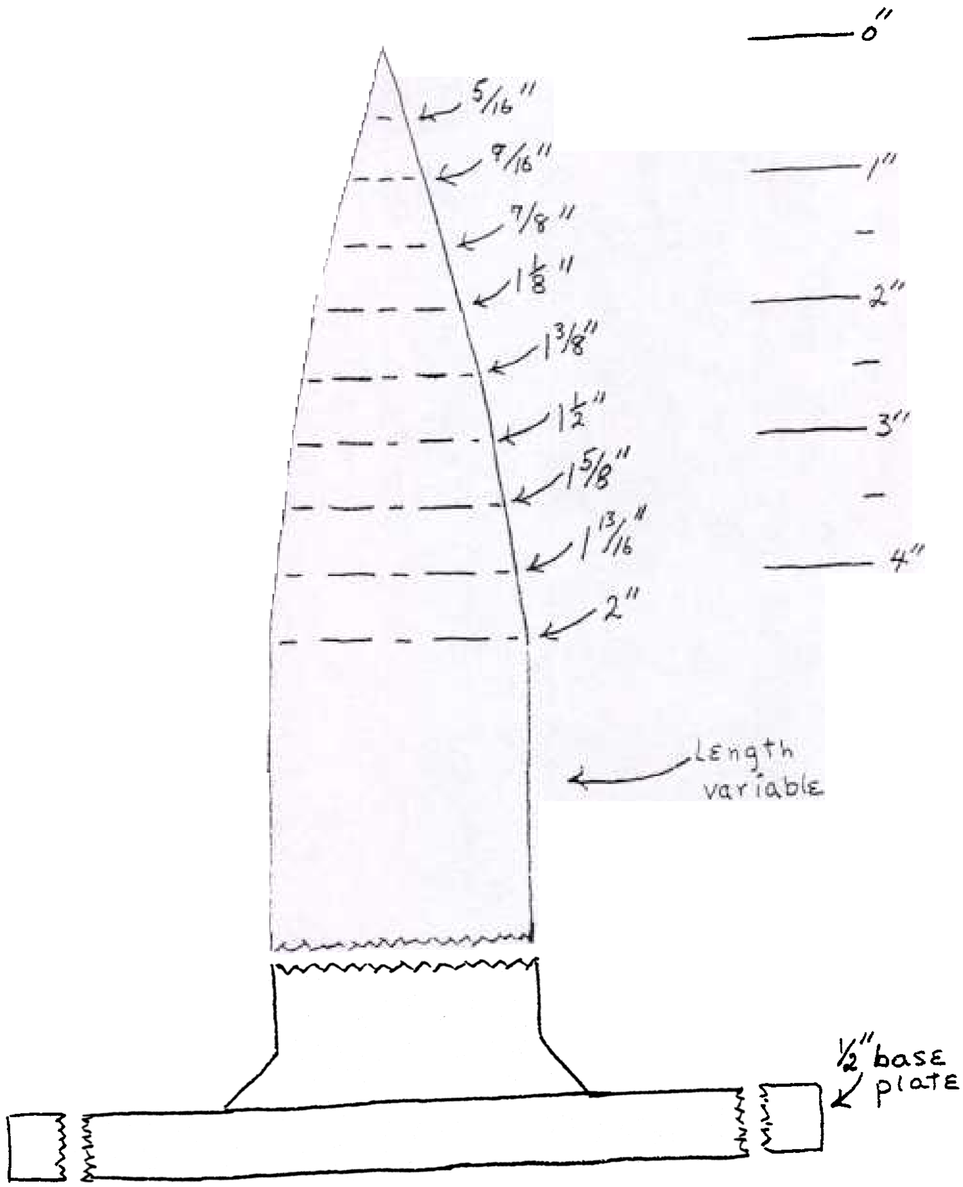
Each slice of the six test bales was evaluated for the presence of mold, feel of dampness, appearance of dustiness, ease of separation and smell. The number of bale slices in the six bales ranged from 16 down to 14 with vented bale averaging 15 and the conventional bales 14.7. Bale slices from vented bales separated easily and cleanly. Bale slices from conventional bales were difficult to separate. Vented bales exhibited no dustiness nor did the conventional bales. One of the vented bales (32.2% moisture) showed no mold, a second (20.6% moisture) contained one slice with about 5% of the mass involved. The third bale (26.3% moisture) contained two slices with grass that were molded to 30% of the mass involved. All bales produced a strong tobacco odor. All conventional bales contained slices that were 100% involved with mold. Most conventional bale slices contained some mold. Mold-free slices for vented bales numbered 42 out of 45 vs. conventional bales numbering 7 out of 44.

Analysis for chemical components showed no trends favoring vented bales (Table 1). Averages of components of all samples taken from layer three of the stack did indicate that the stack heating increased the ash, crude protein and crude fiber as might be expected (Table 2).

CONCLUSIONS

Because of the limitations of the design of this study a number of questions still remain, but some trends are obvious. The vented two-wire bales did contain less molded slices and the slices did break apart cleanly. Interior temperatures of vented bales were cooler, but not greatly so. The study probably did reach the limit of beneficial effects of venting two-wire bales at the moisture levels in the bales and stage of curing of the alfalfa. Those growers having problems with uneven windrow drying should benefit from the practice if they don't take it to the limits that we did. Another point the study brings to mind is that internal temperature peaks in vented bales with moisture levels similar to those in the study may be reduced by leaving a narrow air space between bale wagon loads when field stacking.

We don't know what the effect venting would have on three-wire bales which would have two vents, other than grower and dairyman comments. Two vents may make the practice even more beneficial. A larger diameter vent in a two-wire bale might even further improve conditions. Another question arises about the control of browning. A very slight tobacco odor would certainly sell a lot of summer hay that stays in the stack for six to eight months. Would the vented bale allow us to control and limit the reaction? It's something to think about.



CANADAS BALE VENTILATOR

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(Diagram 1)

TABLE 1

	VENTILATED STACK					CONVENTIONAL STACK				
		Temperature Monitored			Temperature Monitored			Temperature Monitored		
Bales	1	2	3	4	5	6	7	8	9	10
Initial moisture		32.2	20.6		26.3	23.7		30.5	30.4	
Final Moisture		13.2	14.7		17.3	15.5		19.3	16.6	
Peak Interior Temp. °F		118	118		125	122		131	115	
Peripheral Temp. °F										
6/9	85	86	91	93	92	99	99	96	97	85
6/12	81	85	85	86	86	90	92	90	90	82
Crude Protein										
5/23		21.2	22.1		23.3	20.6		25.0	23.2	
6/28		25.1	24.5		22.5	24.5		25.1	23.4	
Ash										
5/23		15.8	14.5		15.8	14.4		13.1	14.4	
6/28		13.7	13.6		14.4	14.7		19.0	16.7	
Crude Fiber										
5/23		22.5	23.1		23.6	23.4		24.7	20.8	
6/28		24.8	24.9		25.8	22.5		24.2	23.3	

TABLE 2

Date Sampled	5/23	6/28
Crude Protein	23.3	24.3
Crude Fiber	23.4	24.3
Ash	14.5	15.4