DOES AN ALFALFA HAY PRESERVATIVE PAY IN THE HIGH DESERT?

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Abstract: Four trials were established in the high desert of Southern California to evaluate the effectiveness and economic feasibility of using a hay preservative in an extremely arid environment. Treatments were an untreated high-moisture check, a buffered propionic acid, a bacterial inoculant, and a dry check. The three high-moisture treatments had better leaf retention and less leaf shatter. However, there was no difference in yield or quality of the hay averaged over the four test periods. Mold and off-color hay was observed in bales from all three high-moisture treatments. There was no significant improvement in color or the degree of mold when a preservative was used. Although not statistically significant, there was a slight improvement in preservation with the buffered propionic acid treatment. It was concluded that the use of an alfalfa preservative would not be cost effective in the high desert in most situations.

Keywords: Harvesting, Baling, Additives, Quality, Spoilage, Mold, Moisture testing.

INTRODUCTION

The baling operation is unquestionably one of the most crucial phases of alfalfa hay production. When alfalfa is baled under improper conditions, both forage yield and quality suffer. Alfalfa baled at too high a moisture content can mold, turn off-color (an olive green or even a tobacco brown), and lose some of the nutritional value. Under the proper environmental conditions and an excessively high moisture content, spontaneous combustion of the hay stack can even occur. On the other hand, alfalfa hay baled too dry is often dusty, and significant leaf shatter and leaf loss can occur. This can result in a reduction in hay quality since leaves are much higher in nutritional value than stems.

In the high desert valleys of Southern California, this second situation is often the case. The arid environment, combined with high temperatures and frequent winds (even during morning hours), make for extremely dry baling conditions. There is frequently insufficient dew or humidity to soften the leaves, and therefore substantial leaf loss results. The leaves that do remain in the bale are often shattered and detached from the stem. A successful technique involving watering alfalfa windrows to simulate natural dew has been developed. This practice was proven to increase yields, improve leaf retention, and enhance the integrity of the alfalfa flake. However, this practice is an extra step, which involves additional labor and equipment.

An alternative to adding water by spraying alfalfa windrows may be to rely on the moisture inside the alfalfa stem, rather than dew or applied moisture. This can be done by baling the alfalfa at a higher moisture content than customarily practiced. Hay baled at this moisture content would need to be treated with a preservative to prevent spoilage. Considerable research has been conducted, primarily by researchers in New Mexico and the Midwest, on the use of preservatives. However, the results have been variable, both in terms of the effectiveness of the products and the economic justification of their use. The incentive for using a preservative and the economic considerations are different in California than in the Midwest. The Midwest does not experience the same favorable curing conditions we are usually blessed with in the Southwest, and the threat of rain is a constant worry. The most important potential advantage for high-desert growers is increased hay quality, which is achieved by minimizing leaf shatter and loss by baling high moisture hay. The other potential

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advantages parallel those associated with reduced curing time. These advantages include a reduction in the effects of windrow shading, minimization of wheel traffic damage to alfalfa regrowth, sooner irrigation after cutting, and better color due to less windrow bleach.

The objectives of this research were to determine the feasibility of using a hay preservative in the high desert and to compare the efficacy of two types of preservatives.

MATERIALS AND METHODS

A series of trials were established in Newberry Springs, located in the high desert of San Bernardino County. The experiment was conducted over four different baling periods to test the practice under a variety of yield levels, and climatic and field conditions. Each baling period was considered a replication. The alfalfa was cut using a Case IH 8840 swather. The dates, windrow width used, harvest operations, and climatic conditions that occurred for each trial are presented in tables 1 and 2.

The treatments consisted of a "wet" check, a buffered propionic acid treatment, a bacterial inoculant treatment, and a "dry" check. The "wet" check was baled at a high moisture content without the addition of a preservative. The buffered propionic acid treatment used was TenderKeep (an 79% active ingredient product from Loveland Industries). It was applied at a rate of eight lbs. (1 gallon) per ton of alfalfa. The bacterial inoculant tested was Pioneer brand 1155 alfalfa hay inoculant. It was applied at the rate of 5 grams of product (dissolved in 1.25 gallons of water) per ton of alfalfa. This product contains strains of _Bacillus pumilus_ and _Bacillus lentus_. Both preservatives were applied using a Harvest Tec Model 440 Preservative Applicator. Two nozzles (Spray Systems 65001 or 65002, depending on desired application rate) were mounted on the hood over the baler pickup with the spray tips oriented toward the gathering chamber of the baler. The propionic acid treatment was applied after the bacterial inoculant to prevent contamination of the inoculant. The "dry" checks were baled without a preservative at a moisture level below 15%. Plots were windrows approximately 1000 ft long. The three high moisture treatments were baled the day after cutting (approximately 22 hours after cutting), except for the last cycle, when the high moisture treatments were baled two days after cutting due to cooler more humid weather. The dry checks were always baled one day after the high moisture treatments. All baling was done between 6:00 and 8:30 in the morning.

Immediately after baling, the bales in each treatment were probed six times with a Delmhorst moisture meter and the moisture readings recorded. Each bale was numbered with an "ear tag" so that it could be identified and monitored during the experiment. Each bale was weighed using a Accu-weigh hanging dial scale. Both ends of the bales were cored using a Penn State Forage Sampler. Samples were stored in plastic bags to determine moisture content and for quality analysis. The alfalfa samples were chemically analyzed for crude protein and ADF.

The bales from each replication were randomly collected with a bale wagon. Each replication made a harrow bed load and was stored apart from other replications. After two months storage, five bales from each treatment for all four experiment cycles (a total of 20 bales per treatment) were randomly selected for further evaluation. The bales were weighed again to calculate their weight loss or percent shrink. The ends of each bale were cored again for moisture and quality determinations. The bales were broken open and evaluated at four locations, two near the ends of the bale and two near the center. The four flakes were scored for color and the presence of mold and/or an off-odor. Core samples were also rated for color, as it was found they were more representative of the entire bale than single flakes. Scores of 1 to 10 were used, where a color score of 1 was dark brown or black, and a score of 10 was bright green. A mold/odor score of 1 signified no visible mold and good odor, and a score of 10 was very moldy with a strong musty odor. The core samples were chemically analyzed for crude protein, ADF, and ADIP (acid detergent insoluble protein, a measure of the bound protein) to determine any losses in quality that may have occurred during storage. These data are not available at this time, as the samples are now being analyzed.

RESULTS AND DISCUSSION

The plots baled at the high moisture content had a significantly higher in-field yield than the dry check plots (table 3). However, after moisture and dry matter losses in storage had occurred, there was no significant difference in yield. There was a trend for the high-moisture treatments to yield higher on the first and second trial dates when baling conditions were poor, with low relative humidity. When baling conditions were good, as in the fourth trial date (relative humidity was 70%, higher than other dates), the dry check yielded as well or slightly higher than the treatments baled at high moisture.

Chemical analysis revealed no difference in quality between hay baled at high moisture and the dry check bales (table 3). Only on the third trial date was there even a trend for the alfalfa samples from the higher moisture treatments to have slightly higher crude protein and lower fiber levels. This is consistent with the results of Crawford et al, where they found little difference (less than one percentage unit) in analyses among high moisture and dry treatments.

Moisture values obtained with the Delmhorst bale probe averaged just slightly higher (0.9 percent) than those obtained from the core samples. Unfortunately, moisture levels obtained from core samples from the first two trial dates appear to be a few percentage points low. The cause for the incorrect values is not understood, but could have been caused by heating of the coring device while drilling the bales, moisture loss from the plastic sample bags, or the samples not being completely oven dried. However, statistical analysis on 104 individual bales from the third and fourth trial dates showed a significant correlation ($r = .81$; $P<.001$) between the average of six Delmhorst moisture readings per bale, and the moisture content of the core samples. The values are not identical, as the Delmhorst uses resistance between two points on the probe to estimate the moisture concentration. Therefore, the Delmhorst reading fluctuates depending on its exact placement in the bale. Core sample and Delmhorst moisture estimates are from somewhat different locations in the bale, yet the values were very close. Thus, the Delmhorst meter was found to be a valuable tool for estimating the moisture concentration.

The percent weight loss in storage was significantly greater with the high moisture bales than in the dry check (table 4). As one would expect, the high moisture bales lost significantly more weight, 17.9 compared to 9.4 percent loss for the dry check bales. There was not a significant difference in weight loss between the high moisture treatments. After approximately two months storage, the moisture content of the bales had equilibrated, and there was no significant difference in moisture content between any of the treatments.

Leaf attachment and appearance were far superior in the bales from the high-moisture treatments. Many of the leaves in the dry check bales were shattered and detached from the alfalfa stem (except for the fourth trial date when the relative humidity was higher, and even the dry check bales had good leaf retention). Bales from all of the high moisture treatments contained good flakes that maintained their integrity when handled. In contrast, many of the flakes from the dry-check bales would fall apart when handled.

Treatments had a significant effect on the color of the bales (table 5). The dry check bales had a bright green color with an average color rating of 9.6. Many of the high-moisture bales had turned tobacco brown, indicating heating. Even where the color had not turned brown, the green approached an olive green color and was not as bright as the color of the dry check bales. There was no significant difference in color between the untreated high moisture check and the bales that received a preservative treatment. However, there was a trend for the Tenderkeep-treated bales to have slightly better color. The outer flakes had superior color to the inner flakes. A probable explanation for the difference is that there is greater air exchange between the outer portions of the bale and the environment than there is with the inner portion of the bale.

Preservative-treated bales from the first trial date had the lowest color ratings and the highest degree of mold and musty odor, despite being baled at a lower moisture content than the third and fourth trial dates. High-moisture bales from the first trial date were also the heaviest (averaging 143 lbs/bale). The grower was not accustomed to baling at such high moisture and did not lower the bale tension sufficiently to reduce the bale weight to a more typical weight. The heavy weights (high bale density) probably restricted air exchange and moisture dissipation into the ambient air. This most likely caused the increased spoilage observed in the preservative-treated bales of the first trial date.

Although not statistically significant, the buffered propionic acid treatment, TenderKeep, appeared to preserve bales slightly better than the wet check or the bacterial inoculant treatment. Propionic acid performs very well in most tests in the literature. However, the propionic acid application rates evaluated generally range from 20 to 40 pounds. Perhaps the propionic acid treatment would have worked better had it been evaluated at a higher rate. The rate tested (8 lbs/ton) was selected, as this is the maximum rate we felt could be justified economically. In an overview article on hay additives by Mahanna, studies by Sheaffer and Martin, Grant, and Walgenbach are cited as concluding that acid preservatives may not be economical unless used to avoid rain damaged hay.

The bacterial inoculant, Pioneer brand 1155, did not improve preservation. This is in agreement with the results of Rotz et al, where they concluded that heating, storage dry matter loss, quality, and appearance of inoculated hay were similar to, or worse than, that of untreated hay.

Most of the studies presented in the literature were conducted on smaller two-wire bales, with an average bale weight between 60 and 80 lbs. This study was conducted on three-twine bales, with an average bale weight for the high-moisture treatments of 128 pounds. Air movement may be less in the denser and larger bales used in this study. This may also account, at least in part, for the poor performance of the preservatives.

The use of a hay preservative may have proven more beneficial had the hay been slightly drier at the time of baling. However, this underscores the difficulty in trying to bale hay with "stem moisture" as it is drying. The optimum moisture range for baling with a preservative may have occurred at 10 or 11:00 the morning after cutting, rather than between 6 and 8:30 a.m. when we baled. Unfortunately, it is not feasible to wait past 8:30 a.m. to bale. Leaves loose moisture far more rapidly than stems. The relative humidity after 8:30 a.m. drops to such a degree that leaf loss would be excessive, despite an average hay moisture of 16 to 20 percent. The relative humidity normally does not climb again to a level suitable for baling until 6:00 a.m.the following day, when the alfalfa can then be baled safely without a preservative.

CONCLUSIONS

The title of this article posed the question "Does an Alfalfa Preservative Pay in California's High Desert?". The answer to that question is probably NO, under most circumstances. By simply waiting one additional day for the alfalfa to dry, the hay can be baled without a preservative and experience no mold or color problems. While the bales from the high moisture treatments had more full and attached leaves and flaked better, the color of the bales was inferior to the dry check bales. There was also mold and a musty odor present in some bales from both preservative treatments. Chemical analysis showed no difference between bales from the high moisture treatments versus the dry check bales. Averaged over all four trials, there was also not a significant difference in yield between high moisture and dry check bales after storage.

The overwhelming majority of the alfalfa produced in the high desert is sold to retail feed stores which, in turn, sell the hay to horse owners. This market will not tolerate any mold, and color is one of the most important criteria used when buying alfalfa. A preservative may be useful on occasions to avoid rain damage or to selectively treat "low spots" in the field or other areas that typically have high moisture. However, based on these results, daily or routine use of an alfalfa preservative would not pay in the high desert.

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Table 1. Dates and conditions of each experimental baling period.

Trial	Date Cut	Baling Date High moist.	Baling Date Low Moist.	Windrow Width[1]	Ave. No. Bales/Treatment
1	7/5	7/6	7/7	5 ft.	11
2	7/6	7/7	7/8	5 ft.	11
3	7/17	7/18	7/19	7 ft.	22
4	8/15	8/17	8/18	5 ft.	8

[1]5 foot windrows baled directly out of the swath. 7 foot windrows raked and combined at 6:00 p.m. on 7/17.

Table 2. Relative humidity and temperature at the timing of baling.

Trial	Relative Humidity High moist.	Relative Humidity Low Moist.	Temperature High moist.	Temperature Low moist.
	%	-----------	----------	°F
1	58	56	68	70
2	56	51	70	70
3	62	58	76	77
4	65	70	64	63

Table 3. The effect of moisture concentration at the time of baling on the yield and quality of alfalfa.

Trial	Treatment[1]	Field Yield	Storage[2] Yield	Crude Protein	ADF
		----- Tons/A	----	------ %	
	High moisture	1.66	1.39	17.4	30.6
	Dry Check	1.32	1.22	18.0	23.7
2	High moisture	1.31	1.06	19.7	31.7
	Dry Check	1.06	0.95	21.1	30.7
3	High moisture	1.82	1.45	21.1	30.4
	Dry Check	1.67	1.49	19.2	32.4
4	High moisture	1.29	1.07	20.5	33.6
	Dry Check	1.24	1.12	20.4	33.9
Mean					
	High moisture	1.52	1.24	19.7	31.6
	Dry Check	1.32	1.20	19.7	30.2
Probability		.05	NS	NS	NS

[1]High moisture values are an average of the wet check, 1155, and TenderKeep, as there is no difference in yield or quality between treatments.
[2]Yield adjusted for moisture and dry matter losses that occurred after approximately 2 months storage.

Table 4. Moisture measurements, weight loss, and average bale weight of preservative-treated and untreated alfalfa hay.

Trial	Treatment	Average[1] Delmhorst	Core[2] Moisture	Weight Loss	Ave. Bale Weight (lbs)
		-------------- %			
1	Wet Check	19.2	-	17.5	137
	1155	20.4	-	17.6	150
	TenderKeep	18.2	-	13.0	143
	Dry Check	-	-	7.4	107
2	Wet Check	18.7	-	17.5	126
	1155	20.7	-	21.2	135
	TenderKeep	18.4	-	16.8	125
	Dry Check	-	-	10.4	117
3	Wet Check	24.2	24.0	24.8	112
	1155	20.1	18.9	18.9	108
	TenderKeep	19.0	19.0	17.7	109
	Dry Check	-	8.3	10.3	94
4	Wet Check	21.4	21.1	16.4	129
	1155	22.7	19.7	16.2	134
	TenderKeep	22.0	19.3	17.2	127
	Dry Check	13.3	12.3	9.3	108
Mean					
	Wet Check	20.9	22.6	19.0	126
	1155	21.0	19.3	18.5	132
	TenderKeep	19.4	19.1	16.2	126
	Dry Check	-	10.3	9.4	107

[1]Delmhorst readings were not possible for the dry checks for the first three trials, as the moisture was too low to register a reading.
[2]Core moisture values were incorrect for the first two trials.

Table 5. Visual color and mold/odor ratings of preservative-treated and untreated alfalfa hay.

Trial	Treatment	Color Rating[1] End	Color Rating[1] Center	Mold/Odor Rating[1] End	Mold/Odor Rating[1] Center	Core Color Rating
1	Wet Check	7.2	6.1	2.5	3.7	6.4
	1155	6.0	5.7	4.5	4.8	4.5
	TenderKeep	7.0	5.4	3.1	4.5	4.7
	Dry Check	9.7	9.3	1.0	1.0	8.0
2	Wet Check	7.7	7.2	2.4	3.2	6.7
	1155	6.9	5.8	3.1	4.7	5.1
	TenderKeep	8.6	7.8	1.5	2.4	6.7
	Dry Check	10.0	10.0	1.0	1.0	8.4
3	Wet Check	6.5	6.2	4.2	4.1	5.8
	1155	8.2	7.8	2.2	2.9	7.6
	TenderKeep	7.6	7.5	2.7	3.1	6.0
	Dry Check	9.2	9.2	1.0	1.0	9.0
4	Wet Check	6.9	6.1	3.3	4.4	5.0
	1155	7.3	6.3	3.0	4.0	7.0
	TenderKeep	8.5	7.1	2.0	3.4	6.8
	Dry Check	9.9	9.9	1.0	1.0	9.8
Mean						
	Wet Check	7.1	6.4	3.1	3.5	5.9
	1155	7.1	6.4	3.2	4.9	6.1
	TenderKeep	7.9	7.0	2.3	3.3	6.1
	Dry Check	9.7	9.6	1.0	1.0	8.8
LSD .05		1.0	1.2	1.2	1.1	1.6

[1]End refers to evaluations made on flakes near the ends of the bale. Center refers to evaluations made toward the center or interior of the bale.

Rating 1 = brown or black color 10 = bright green
1 = no mold and good odor 10 = very moldy, strong musty odor