

Technologies to Remoisturize Alfalfa in the Windrow for Baling

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Introduction

Highlights

- Having the correct moisture at the time of baling is critical to maximizing economic return.
- Researchers at Utah State University studied new technologies that introduce moisture to the windrow artificially for effectiveness, allowing a single baler to cover more acres per day and produce bales at a consistent moisture level.
- The study showed that yields from moisture treatments were greater on a per-acre basis than those baled dry.
- No differences in forage nutritive values were detected as statistically significant in this study.
- Moisture-treated bales were always more appealing to brokers than those baled dry.
- Producers can estimate the annual ownership cost using the capital recovery method.

Perhaps no other harvest-related issue garners more attention from alfalfa growers than the moisture level of the crop in the windrow. In hay production, the goal is to dry the cut forage as quickly as possible to limit exposure to outside elements and to minimize the impact on growth of the next cutting. Having the correct moisture at the time of baling is critical to maximizing economic return. Alfalfa baled too wet can be subject to spoilage, discoloration, loss of dry matter during storage, and, in

extreme cases, combustion. When alfalfa is baled too dry, leaves and stems become brittle and shatter, leading to yield loss, dust, and decreased forage quality. Regardless of whether the hay is used on the farm to feed livestock or sold, its value is reduced if it is baled outside of the proper moisture range of 12%–18% (Missouri University Extension, 1993).

In dry climates, like Utah, where alfalfa is widely grown, dew has long been relied on to provide needed moisture to the hay in the windrow to protect leaves and stems from shattering during the baling process. The challenge with natural dew is that it can be unpredictable, both in terms of timing and amount. As a result, producers typically work their baling schedules around weather conditions and often encounter a wide range of windrow moisture levels throughout a field.

To address the need for dew, technologies have been developed to introduce moisture to the windrow artificially. Early efforts consisted of a producer loading a sprayer with water and applying it over the top of the raked forage. More recently, specialized equipment that injects moisture into the windrow during the baling process has been developed. The manufacturers' claim is that these systems extend the window for baling, allowing a single baler to cover more acres per day and produce bales at a consistent moisture level.



While possibly useful, these technologies require significant initial investment, and there has been limited research evaluating their effects. In 2020 and 2021, researchers at Utah State University (USU) studied moisturization technologies to determine their impact on alfalfa yield, quality, and economic return.

On-Farm Experiment Procedures

Researchers conducted studies during the second and third cuttings in 2020 and the second cutting in 2021 on a large, pivot-irrigated farm near Milford, Utah. A different field was used for each cutting due to the difficulty of

predicting the speed of alfalfa dry-down and the need to coordinate the experiment's logistics several weeks in advance. Fields used in the experiment were consistent in that each had good alfalfa density and vigor and each was well-managed in weed and insect control, soil fertility, and irrigation. Prior to baling, alfalfa was swathed and raked in accordance with normal farm practice.

Treatments included four different remoisturizing methods:

1. DewPoint Steamer (Staheli West DewPoint Steamer)
2. Treat-and-bale (Harvest Tec Dew Simulator)
1. Treat-and-wait (Harvest Tec Dew Simulator)
2. No treatment (dry)

The DewPoint Steamer was set to apply at 95% steaming capacity, while the Dew Simulator was set to treat at 16 and 18 gpm for treat-and-bale and treat-and-wait, respectively (Figure 1). Treat-and-bale consisted of baling approximately 5 seconds after treating with the Dew Simulator. Treat-and-wait consisted of baling approximately 10 minutes after treating.

Figure 1. The Baler Used for All Experiment Treatments Was Outfitted With a Staheli West DewPoint Steamer (left) and a Harvest Tec Dew Simulator (right)



Photo: Bryant Henningfeld, Harvest Tec

After raking the field, baling for all three harvests occurred that evening between the hours of 9 p.m. and 1 a.m., with a Massey Ferguson 2270 large square baler operating at 45 to 50 flakes per bale at an average speed of 8 mph. The baler was equipped with a DewPoint Steamer, but

the steamer was only used to treat the windrow for its designated treatment. Two individual pivot spans were designated as blocks in the experimental design. The four treatments were randomly assigned to windrows within a single pivot span. After those four windrows were baled, the treatments were re-randomized and applied to windrows in a second pivot span. Five to seven bales were made for each treatment; the first two to four bales made were not included in the evaluation to allow for pre-run adjustments. Three consecutive bales from each run were then tagged for later identification and coring (Figure 2).

Figure 2. Bale Produced While Using a Staheli West DewPoint Steamer (top), Harvest Tec Dew Simulator (middle), and Dry, Without Added Moisture (bottom)



For each treatment, three bales (replications) were evaluated per block, resulting in a total of six bales (replications) per treatment per cutting (2 blocks x 3 bales). Researchers recorded each bale's moisture from the moisture meter on the baler. The following morning, individual bales were sampled following the National Forage Testing Association (NFTA) recommendations for coring (a composite of six cores, three per end on a diagonal) and analyzed by near-infrared (NIR) at Dairyland Laboratory in Jerome, Idaho, to test neutral detergent fiber (NDF), relative feed value (RFV), and crude protein (CP). The length of windrow required to produce each bale was marked and measured, and the area was calculated as the length and width of the respective windrow. Bales were individually weighed on an electronic scale. The measured area and bale weight were used to calculate yield. Statistical analysis was conducted by ANOVA and means separated using the LSD method at the 5% level of probability ($P = 0.05$). There was no treatment by cutting interaction, so data were combined and analyzed across cuttings (6 bales per treatment x 3 cuttings = 18 total bales per treatment).

How Did the Different Technologies Perform?

Bale Moisture and Weight

In all cuttings, moisture was higher in treated bales (13.3% moisture on average) than in those baled dry (8.1% moisture; Table 1). Differences in moisture between bales that received the moisture treatments were rare and inconsistent. As expected, the weights of moisture-treated bales (1,449 pounds per bale on average) were greater than those baled dry (1,347 pounds). Bales produced with the DewPoint Steamer were generally heavier (1,483 pounds) than those made using the Dew Simulator (1,432 pounds on average).

Yield

When not adjusted for moisture, yields from moisture treatments were greater on a per-acre basis than those baled dry (0.13 tons/acre increase, on average). No statistical yield differences were detected between the DewPoint Steamer or the Dew Simulator in any of the cuttings; however, the DewPoint Steamer and Dew Simulator treat-and-bale had significantly higher yield than the dry treatment, whereas treat-and-wait was not significantly better yielding than the dry treatment.

Table 1. Moisture, Bale Weight, Yield of Alfalfa of Large Square Bales Treated With Different Technologies to Remoisturize Alfalfa Windrows Near Milford, Utah, in 2020 and 2021

Treatment	Moisture (%)	Bale weight (lb)	Yield, with moisture (tons/acre)	Yield, dry matter (tons/acre)
DewPoint Steamer	13.1	1,483	1.42	1.26
Dew Simulator, treat-and-bale	13.8	1,436	1.46	1.28
Dew Simulator, treat-and-wait	13.0	1,427	1.38	1.22
Dry	8.1	1,347	1.29	1.18

Treatment	Moisture (%)	Bale weight (lb)	Yield, with moisture (tons/acre)	Yield, dry matter (tons/acre)
Least significant difference (LSD)	0.7	24.5	0.10	0.09

Note. Values in the same column with the same letters are not statistically different ($P = 0.05$).

When adjusted for moisture (expressed on a dry matter basis), yields from moisture treatments were greater on a per-acre basis (0.07 ton/acre increase, on average) compared to those baled dry. However, treat-and-bale was the only treatment that was significantly higher yielding (1.28 tons/acre) than alfalfa baled dry (1.18 tons/acre). The lack of difference in yield was surprising due to potential dry matter loss due to leaf and stem shatter by baling dry alfalfa at around 8% moisture. This suggests that the baler was able to capture a large percentage of the shattered and dusty alfalfa and package it into the bale.

- Crude protein (CP)
- Neutral detergent fiber (NDF)
- Relative feed value (RFV)

Quality

No differences in forage nutritive values were detected in this study (Table 2). Although numerically, the dry bales trended toward lower quality (lower CP and RFV, and higher NDF), the differences were not statistically significant. The fact that the lack of moisture during baling did not adversely impact forage quality is surprising due to the importance of leaf material in shaping the nutritive value of the bale. This suggests that, although shattered and unattached, the leaves in the dry bales were mostly captured during baling and present in the core sampling process.

Table 2. Nutritive Values (CP, NDF, and RFV) of Large Square Bales Treated With Different Technologies to Remoisturize Alfalfa Windrows Near Milford, Utah, in 2020 and 2021

Treatment	Protein	NDF (%)	RFV
DewPoint Steamer	22.2	37.7	163
Dew Simulator, treat-and-bale	22.2	37.8	164
Dew Simulator, treat-and-wait	22.3	37.5	166
Dry	22.1	37.1	161
LSD	NS	NS	NS

Note. Columns with "NS" are not statistically different at $P = 0.05$.

Storage in the Stack

After 3 months of storage in a stack, bales produced in the 2021 cutting were re-evaluated for weight, moisture, and quality to determine if differences in bale characteristics would persist. After storage, bale moisture content across all moisture treatments declined an average of 2.2% (Table 3). Bale weights did not change during storage with the DewPoint Steamer but decreased slightly with the Dew Simulator treatments. In contrast, dry bale moisture increased 1%, and bale weight increased 26 pounds during the same period of storage. All forage quality measures were affected by storage (Table 4). Protein decreased 0.6%, NDF increased 1.7%, and RFV dropped 9 points. The data from this study suggest that bale weight, moisture, and quality may be better in hay tested at harvest rather than after storage in the stack.

Table 3. Bale Moisture, Bale Weight, Yield of Large Square Alfalfa Bales Treated With Different Technologies to Remoisturize Alfalfa Windrows During Second Cutting Near Milford, Utah, in 2021

Treatment	Moisture (%) at harvest	Moisture (%) after storage	Bale weight (lb) at harvest	Bale weight (lb) after storage
DewPoint Steamer	13.8	12.1	1470	1470

Treatment	Moisture (%) at harvest	Moisture (%) after storage	Bale weight (lb) at harvest	Bale weight (lb) after storage
Dew Simulator, treat-and-bale	14.4	11.2	1420	1390
Dew Simulator, treat-and-wait	14.4	12.9	1457	1413
Dry	8.3	9.3	1317	1343
LSD	1.3	1.1	41	51

Notes. Bale moisture at harvest was measured on the baler, while moisture after storage was determined with a hand-held moisture probe. Values in the same column with the same letters are not statistically different ($P = 0.05$).

Table 4. Nutritive Values (CP, NDF, and RFV) of Large Square Bales Treated With Different Technologies to Remoisturize Alfalfa Windrows During Second Cutting Near Milford, Utah, in 2021

Timing	Protein	NDF	RFV
At harvest	22.2	37.7	163
After storage	22.2	37.8	164
LSD	0.49	1.097	6.68

Note. Values in the same column with the same letters are not statistically different ($P = 0.05$).

Visual Appearance

After stack storage, two hay brokers evaluated the visual appearance of the bales to provide an assessment of how the bales produced using moisturizing systems may influence marketing. The brokers did not know which treatment was applied to any of the bales to avoid potential bias. Moisture-treated bales produced by the DewPoint and Dew Simulator did not differ from each other and were always more appealing to brokers than those baled dry. Bales produced with both the DewPoint and Dew Simulator (leaves intact and attached) had a much better appearance than those baled dry (shattered leaves

and stems, dusty). In terms of 2021 market value, the moisture-treated bales were priced at \$280–\$285/ton, while the dry bales had a value of \$270/ton.

Figure 3. *Post Storage Re-Evaluation of 2021 Bales for Weight, Moisture, and*



Quality Notes. After 3 months in a stack, researchers determined if differences in bale characteristics would persist and to assess the visual appearance of the bales and how it would influence marketing.

Economic Analysis

The economic analysis of these different alfalfa remoisturizing technologies uses only statistically significant variables. In this analysis, yield was found to be statistically significant. The average yield from the three cuttings for the dry bale was 1.29 tons per acre, the Dew Simulator was 1.42 tons per acre, and the DewPoint Steamer was 1.42 tons per acre. Based on the scenario of 1,000 acres and three cuttings, using either the DewPoint Steamer or the Dew Simulator would result in an additional 0.13 tons per acre or 390 tons of alfalfa. These estimated additional tons will be the basis for the economic analysis.

Understanding Partial Budgeting

Partial budgeting is a decision tool to help analyze financial impacts of changes to an operation. Partial budgeting does not include all costs and returns but includes added costs for remoisturizing technology in an alfalfa operation. The cost of baling remains fixed, and the financial impact of including remoisturizing technology will be analyzed. The four key components to a partial budget are (1) increased income, (2) reduction or elimination of costs, (3) increased costs, and (4) reduction or elimination of income. The net impact will be the positive changes minus the negative changes. Table 5 helps to identify these changes.

Table 5. *Partial Budget Categories*

Added income	Added costs
- Increased bale weights result from incorporating steam technology. - DewPoint Steamer: Additional 0.13 tons (260 lb) per acre - Dew Simulator: Additional 0.13 tons (260 lb) per acre - Additional tons per acre $\times$ hay price = Additional income	- Increased costs are associated with including the steam technology. - Annual ownership cost + Operating cost = Total cost

Capitol Recover Method

Annual ownership cost is estimated by using the capital recovery method. The capital recovery method includes the purchase price, salvage value, useful life, and a discount rate. The assumed useful life used in this analysis was 5 years. This implies that the ownership cost of owning the equipment is spread equally over the 5 years. The discount rate represents the opportunity cost of capital and accounts for the value of owning the piece of equipment over multiple future periods. The operating costs are estimated as fuel used per hour, labor costs, and repair costs on an annual basis. Based on data in Table 1, the net financial impact assuming 1,000 acres of alfalfa, three cuttings per year, a fuel price of \$2.50/gallon, and an alfalfa price of \$200/ton is \$11.28/acre for the DewPoint Steamer and \$20.28/acre for the Dew Simulator (Table 6).

Table 6. *Total Costs Associated With Hay Moisturization Technology Options*

Category	DewPoint Steamer	Dew Simulator
Annualized cost of ownership	\$44,170.59	\$14,608.49
Total operating cost	\$18,531.00	\$9,755.00
Total cost	\$62,701.00	\$24,363.00
Benefits per acre	\$26.00	\$26.00
Costs per acre	\$14.72	\$5.72
Net benefits per acre	\$11.28	\$20.28

The annual cost of ownership is estimated based on one scenario, so use caution when drawing specific conclusions. The DewPoint Steamer has a higher ownership cost, which increases the per-acre cost. This cost is reduced as the number of acres increases. These results also assume that both steam technologies are used over 100% of the acres. Decreasing usage will impact the results for both technologies. A key factor not addressed in the analysis, due to year-to-year variations, is the price premium associated with higher-quality alfalfa. There is the potential that steamed alfalfa could have an associated price premium. A higher price premium would increase the overall economic value associated with both the DewPoint Steamer and Dew Simulator technologies. Producers should use the partial budgeting methodology to analyze the results for their specific operation.

Conclusion

In this study, both technologies tested to remoisturize alfalfa hay were successful in increasing bale weight and yield. The weight increase was primarily due to increased moisture content in the bale and only a slight increase in dry matter yield. Forage nutritive values of individual bales were not improved by remoisturizing hay in the windrow. The visual appearance of bales produced using moisturizing systems, compared with those baled dry, was much more attractive and would likely influence marketing. A partial budgeting strategy can be used to analyze the potential returns of these technologies, with results that depend on the size and needs of a specific operation.

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