Impact of Moisture Added At Lint Slide On Cotton Color

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Abstract

THIS STUDY evaluated the impact of bale moisture on fiber quality characteristics during storage for 116 days. Water (0, 13, 20, 48 and 55 pounds per bale) was sprayed over the top of the fiber as it came down the lint slide.

The bales were packaged at universal density. Initial moisture contents after the water was added and before storage ranged from 6 percent to 15.4 percent. After 116 days of storage the bale in which no over spray had been applied had increased to 6.1 percent moisture content, all the other bale moistures had changed substantially even though the bales were triple-sealed in polyethylene bags.

Most fiber quality characteristics except color remained about the same. The HVI color decreased from Middling (31) to Strict Low Middling Spotted (43) as final bale moisture content increased from 6.1 percent to 12.9 percent.

Introduction

Cotton is hygroscopic and continually seeks to reach equilibrium with the moisture in the air. When the cotton fiber is not compressed, it gives up moisture readily at low humidity but absorbs moisture much more slowly at high humidity unless wetting agents are used. After the cotton fiber is packaged into a bale, moisture transfer occurs very slowly especially at high densities.

In fact, bales at densities of 12 lb/ft^3 required over 60 days to equilibrate with the environment while bales at 28 lb/ft^3 required over 110 days (Anthony, 1982), obviously, equilibration time is a function of the starting moisture as well as the humidity and temperature of the environment.

The bales attempt to reach equilibrium with the environment and the rate of adsorption and desorption is influenced by bale density, ambient temperature and humidity, bale covering, surface area, air changes, fiber history, etc. (Anthony, 1997). Anthony (1982) stored low-moisture bales for periods up to one year and found that moisture gain was a function of density, climatic conditions and bale covering. He considered jute, burlap, woven polypropylene, strip-laminated polypropylene, dimpled polyethylene and polyethylene. Bales covered in the relatively impermeable polyethylene required much more time (over 365 days) to equilibrate with the environment than the other bale coverings (over 120 days).

Ginners often restore moisture at the lint slide to reduce bale-packaging forces and to recover the weight lost during field drying and gin processing (Anthony, Van Doorn and Herber, 1994). Two basic methods are used-humidified air and direct water spray. The humidified air approach rarely adds more than 2 percent moisture to a bale but the direct spray approach can add far more. Thus, the direct spray approach must be used with great care.

Griffin and Harrell (1957) investigated the effect of adding moisture at the lint slide on lint quality and bale weight for 18 bales packaged at 12 lb/ft^3, covered with jute bagging and stored for 70 days. They considered different amounts of moisture sprayed on the fiber with and without a surfactant with nine nozzles as the lint came down the lint slide.

The amounts ranged from 0 to 82 pounds per bale in 1953-54. They conducted a similar study with six bales in 1954-55 except that the bales were packaged at standard density (about 20 lb/ft^3) and 0 to 35.7 pounds of water was added per bale. In 1953-54, bale moistures ranged from 3.9 percent to 18.8 percent whereas they ranged from 4.6 percent to 9.0 percent in 1954-55. They found that all the bales either gained or lost weight as they tried to reach equilibrium with the atmosphere at about 7 percent moisture content.

Of the 18 bales in their 1953-54 study, no damage could be attributed to the addition of moisture at the lint slide except for the bales packaged at over 15 percent moisture; these bales developed mildew and fungal growth and were not graded. No damage to fiber quality or spinning properties was evident in bales packaged below 9 percent moisture. For the 1954-55 study, the color grade was reduced from Strict Low Middling to Low Middling when moisture was added at the lint slide to raise the moisture content even at storage moistures of 6.2 percent-this happened regardless of the amount added.

They also reported that the center of the bales had not equilibrated with the atmosphere after 91 days. Anthony (1982) found similar results from 100 samples taken throughout bales stored for several months.

Current bale covering materials include burlap, woven polypropylene with laminated strips of polyethylene to prevent fibrillation, and polyethylene with 3/8″ diameter perforations on 18" centers to allow moisture transfer. Anthony and Herber (1991) studied the moisture transfer characteristics of these materials applied over universal density bales that were packaged at 3.5 percent moisture and stored at 70°F and 80 percent relative humidity.

They reported that the woven polypropylene-covered bales reached equilibrium in less than 161 days whereas the polyethylene-covered bales had not reached equilibrium after 378 days. After 161 days, the polyethylene-covered bales had gained about 40 percent as much moisture as the polypropylene-covered bales.

With the exception of the Griffin and Harrell report, published information addresses moisture entering rather than leaving the bale. Barker and Laird (1993) reported that desorption occurs at about twice the rate of absorption for small samples of lint. Thus, bales should lose moisture much faster than they gain moisture.

Rapid measurement of the moisture in cotton bales is very difficult, and becomes even more complex when water is sprayed directly to the cotton at the lint slide. Anthony (2001) reported success with hydraulic methods whereas Byler, Anthony and Galyon (2001) reported acceptable levels of accuracy using patented resistance-based sensors (Byler and Anthony, 1996).

Until suitable methods to measure the moisture of baled cotton are readily available, care must be exercised to ensure that excessive moisture is not added to bales. Based on the work of Griffin and Harrell (1957), bales should not be covered with jute bagging and stored above 9 percent moisture content. This study was undertaken to obtain additional information relative to the impact of moisture on fiber quality.

Purpose

The purpose of this work was to determine if the effects of moisture sprayed on fiber at the lint slide adversely impacted fiber quality, bale packaging and fiber quality during storage.

Methodology

Five bales of Stoneville 4892BR cotton harvested October 11, 2000 were processed through a cylinder cleaner, stick machine, cylinder cleaner, extractor feeder/gin stand, and one saw-type lint cleaner in the full-scale gin at the Stoneville Ginning Lab. As the lint came down the lint slide, three conventional spray nozzles applied plain water to the surface of the cotton. For treatment number 1, no moisture over spray was used. For treatments 2, 3, 4 and 5 the nozzles were equipped with 0.002, 0.003, 0.001 and 0.001-inch diameter tips, respectively.

The three nozzles were connected to a standard residential water hose for water supply. Flow rate was controlled by a needle valve, which also allowed two moisture levels from the 0.001-inch nozzle. The output of the tips at various valve settings was calibrated by capturing the water from the nozzles for a period of time. Water quantities of about 10, 20, 40 and 50 pounds per 500-pound bale of cotton were planned.

About 1400 pounds of seed cotton was ginned to produce each bale for each treatment and the bale was placed in a six-mil thick plastic bag, and then two additional layers of plastic bags were placed over the initial one. The triple-sealed polyethylene covering was used to maintain the moisture in the bale as much as possible. This covering method is not used commercially, but the study was conducted to establish the response of fiber properties to a specific moisture level.

The triple-sealed covering is similar to the single layer polyethylene with 3/8″ diameter holes spaced 18″ apart. Five samples were taken as the cotton came up the lint flue to the battery condenser for High Volume Instrument (HVI) evaluation and nine samples were taken for moisture evaluation. After moisture was added, nine samples were taken for lint moisture evaluation.

The bales were pressed to a platen separation of about 19 inches (Table 1). The bales were then weighed and placed in storage (Figure 1) at ambient conditions for a period of 116 days. The bales were ginned May 25, 2001 and were taken out of storage on September 18, 2001.

After the storage period, the bales were sampled at 10 intermediate locations (layers) about 3-inches apart as shown in Figure 2. The cotton was separated at each layer and samples taken (Figure 3). Sub-samples were taken at each layer for moisture content (10 each) determination by the oven method (ASTM, 1971), Advanced Fiber Information System (AFIS) (5 each), HVI classification (3 each) and biological degradation (10 each).

The 100+ gram samples taken for biological degradation will be analyzed and reported by the USDA-ARS Cotton Quality Research Station at Clemson, South Carolina.

During transit, these samples were stored in doubled Ziploc(tm) polyethylene bags to ensure stable climatic conditions were maintained. HVI classification analysis was conducted by the Agricultural Marketing Service at Memphis, TN, and the lint mois-

Table 1. Initial ginning data and final moisture content.

Moisture level	Bale	Water added, lbs.*	Bale weight, lbs. Initial	Pressure, psi	Bale moisture, % Lint flue	Bale	After 116 days
1	1	0.0	534	2438	6.0	6.0	6.1
2	5	12.8	510	1675	4.8	7.3	7.9
3	4	19.5	514	1664	5.1	8.9	8.2
4	2	47.9	570	1817	5.5	13.9	11.6
5	3	55.3	542	1335	5.2	15.4	12.9

*Calculated from difference in lint moisture.

Table 2. Final moisture content in the bale after 116 days of storage.

Moisture Level	Layer	Mean	Standard Deviation	Minimum	Maximum
1	0	6.06	0.116	5.90	6.30
1	1	6.30	0.123	6.10	6.50
1	2	6.18	0.173	5.95	6.40
1	3	6.03	0.129	5.85	6.20
1	4	6.14	0.119	6.00	6.40
1	5	6.04	0.104	5.90	6.25
1	6	5.91	0.134	5.70	6.05
1	7	6.04	0.080	5.85	6.15
1	8	6.00	0.121	5.80	6.20
1	9	5.90	0.084	5.80	6.05
2	0	7.96	0.395	7.65	8.85
2	1	7.76	0.180	7.50	8.00
2	2	7.86	0.189	7.65	8.20
2	3	8.01	0.163	7.75	8.25
2	4	7.86	0.328	7.55	8.55
2	5	7.95	0.327	7.60	8.65
2	6	8.05	0.219	7.75	8.45
2	7	7.98	0.123	7.85	8.15
2	8	7.72	0.204	7.40	8.00
2	9	8.08	0.324	7.55	8.60
3	0	8.34	0.306	7.95	8.80
3	1	8.24	0.165	8.00	8.60
3	2	8.18	0.233	7.90	8.75
3	3	8.07	0.221	7.80	8.50
3	4	8.20	0.248	7.90	8.75
3	5	8.31	0.313	7.90	8.80
3	6	8.00	0.148	7.85	8.35
3	7	8.24	0.253	7.95	8.80
3	8	8.35	0.319	8.00	8.75
3	9	8.17	0.345	7.90	9.10
4	0	12.37	1.072	11.05	13.85
4	1	11.64	0.346	11.10	12.30
4	2	12.26	1.189	10.95	14.20
4	3	11.70	0.923	10.90	13.70
4	4	11.21	0.443	10.70	11.85
4	5	11.06	0.461	10.45	11.85
4	6	11.28	0.383	10.75	11.95
4	7	10.88	0.332	10.60	11.60
4	8	11.18	0.480	10.75	12.20
4	9	12.36	0.992	11.10	13.45
5	0	13.11	0.848	12.35	14.85
5	1	13.51	1.613	11.60	15.55
5	2	12.04	0.614	11.35	13.40
5	3	11.70	0.427	11.05	12.60
5	4	12.62	1.051	11.45	14.35
5	5	14.24	1.347	11.70	16.20
5	6	12.63	0.805	11.80	14.20
5	7	13.15	1.333	11.80	15.10
5	8	12.97	0.896	12.10	14.40
5	9	13.22	1.011	12.35	15.30

Table 3. Advanced Fiber Information System data after storage.[1]

Moisture content, %	Fiber length by weight, in.	Upper quartile length by weight, in.	Short fiber content by weight, %	Immature fiber content, %	Maturity ratio	Neps per gm	Seedcoat neps per gm	Dust, gm	Trash, gm	Visible foreign matter, %
6.1	0.962	1.154	8.52	3.65	0.895	189	11.8	504	109	1.99
7.9	0.947	1.144	9.04	3.68	0.887	204	10.1	389	91	1.64
8.2	0.944	1.137	8.75	3.56	0.889	202	10.1	390	96	1.70
11.6	0.946	1.142	9.09	3.47	0.896	209	10.6	419	104	1.90
12.9	0.940	1.138	9.39	3.47	0.891	212	10.5	411	101	1.84

[1]Each number is based on 50 subsamples with 3 readings per subsample

Table 4. Average HVI data before and after bale storage.[1]

Level		Moisture %	Rd	+b	Color	Micronaire	Uniformity	Strength, g/tex	Trash,% area	Length in.
1	Before	6.0	75.8	8.6	31	4.4	82.0	29.9	0.36	1.092
	After	6.1	75.7	8.5	31	4.5	83.2	29.2	0.49	1.086
2	Before	7.3	75.6	8.5	31	4.4	82.6	29.2	0.36	1.094
	After	7.9	74.7	8.9	31	4.5	83.2	29.4	0.42	1.084
3	Before	8.9	75.8	8.6	31	4.5	81.8	28.9	0.42	1.088
	After	8.2	73.6	9.3	41	4.5	83.0	29.2	0.48	1.082
4	Before	13.9	76.0	8.5	31	4.5	82.4	30.0	0.42	1.090
	After	11.6	70.6	10.1	42	4.5	83.2	29.0	0.50	1.082
5	Before	15.4	76.0	8.5	31	4.5	82.2	29.2	0.42	1.088
	After	12.9	69.3	10.6	43	4.5	82.6	29.3	0.46	1.086

[1] "Before" data is the average of 5 subsamples for moisture and 9 for HVI, and "after" data is the average 100 subsamples.

Figure 1. Five bales stored in triple polyethylene bags for 116 days under ambient conditions.

ture (ASTM, 1971) and AFIS evaluations were conducted at the Stoneville Gin Lab.

Results

The actual pounds of moisture that were applied to the cotton were 0, 12.8, 19.5, 47.9 and 55.3 pounds water per bale (Table 1). Based on calculations from the moisture levels before and after moisture addition as determined by the oven method, 0, 12, 20, 42 and 48 pounds were added. The initial bale weights were 534, 510, 514, 570 and 542 pounds, respectively. Lint moisture contents in the lint flue prior to moisture being added were 6.0, 5.8, 5.1, 5.5 and 5.2 percent, respectively, for moisture levels 1-5.

The moisture contents after the over spray were 6.0, 7.3, 8.9, 13.9 and 15.4 percent, respectively, for moisture levels 1-5. Compression pressures were 2438, 1675, 1664, 1817 and 1335 psi, respectively for moisture levels 1-5. Visible water damage in the form of yellow or dark discolorations is shown in Figures 4 and 5 and was typical in all bales where moisture was added.

After storage, the final moisture contents were 6.1, 7.9, 8.2, 11.6 and 12.9 percent. Table 2 contains final moisture contents in the bale after storage for each of the layers of cotton within each bale and shows their relative consistency. The bale without any over spray remained relatively constant at 6 percent versus 6.1 percent moisture content.

The bale with limited amount of water added changed its moisture content from 7.3 to 7.9 percent. The bale that had 20 pounds of water added (level 3) changed its moisture content from 8.9 to 8.2 percent. The two bales with the high levels of moisture also lost weight during storage.

Since bale replications were not used, only trends in data can be given. The AFIS data in Table 3 is the average of 5 subsamples at 10 layers and 3 analyses per subsample. It suggests that fiber length, immature fiber, and dust particles were reduced by moisture. Short fiber content, and neps appeared to increase. Sample classification before and after the storage period by the Agricultural Marketing Service is presented in Table 4. The HVI color decreased from Middling (31) to Strict Low Middling Spotted (43) as moisture content increased from 6.1 percent to 12.9 percent (Figure 6). Reflectance or Rd averaged 75.7, 74.7, 73.6, 70.6, and 69.3, while Yellowness (plus b) averaged 8.5, 8.9, 9.3, 10.1, and 10.6, respectively for moisture levels 1, 2, 3, 4, and 5. Thus, the bales became darker and more yellow as moisture increased; even 12.8 lbs of water added per bale increased yellowness and grayness substantially. The analysis of the biological degradation of the samples during storage will be reported later.

Summary

The purpose of this study was to determine if any degradation occurred in the fiber during a three-month storage period. Five bales of cotton were ginned at the U.S. Cotton Ginning Laboratory and varying amounts of moisture were sprayed over the top as the cotton was coming down the lint slide. For these bales approximately 0, 13, 20, 48 and 55 pounds of water was over sprayed on the cotton as the fiber came down the lint slide in layers.

Initial moisture contents after the water was added and before storage ranged from 6 percent for the bale with no over spray to 15.4 percent for the highest amount of water added.

After 116 days of storage the bale in which no over spray had been applied remained at about 6 percent moisture content, all the other bale moistures had changed somewhat even though the bales were triple sealed in polyethylene bags. AFIS measurements indicated that fiber length, immature fiber, and dust particles variables were reduced by the addition of moisture. Short fiber content, and neps appeared to increase with increased levels of moisture.

The HVI color decreased from Middling (31) to Strict Low Middling Spotted (43) as moisture content increased from 6.1 percent to 12.9 percent. Reflectance (Rd) and Yellowness (+b) values indicated the bales became darker and more yellow as moisture increased. Analysis of the biological degradation will be reported after the samples are analyzed at the Cotton Quality Research Station in Clemson, South Carolina.

Disclaimer

Mention of a trade name, proprietary product, or specific machinery does not constitute a guarantee or warranty by the U.S. Department of Agriculture and does not imply approval of the product to the exclusion of others that may be available.

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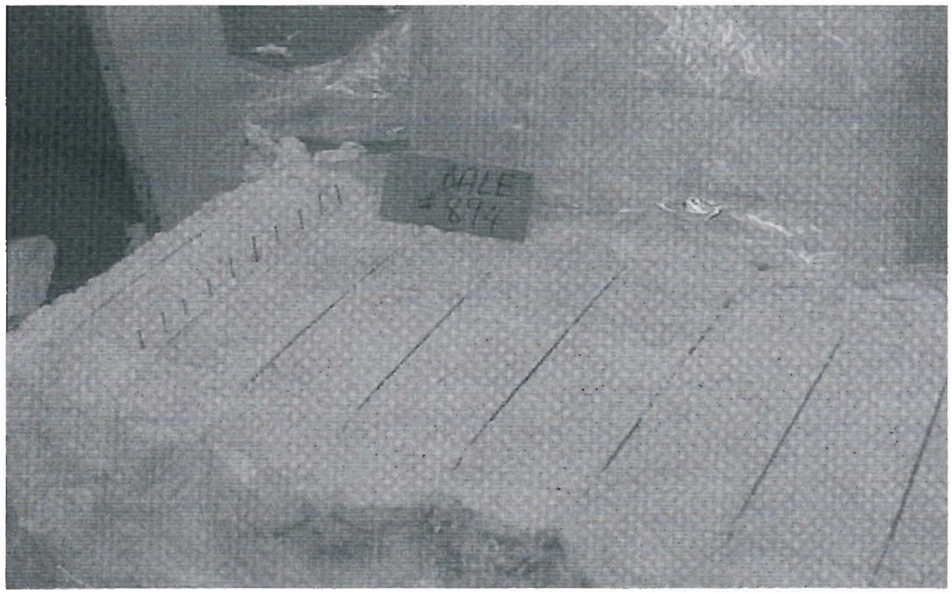

Figure 2. Typical bale divided into 10 layers about 3-inches apart before sampling.

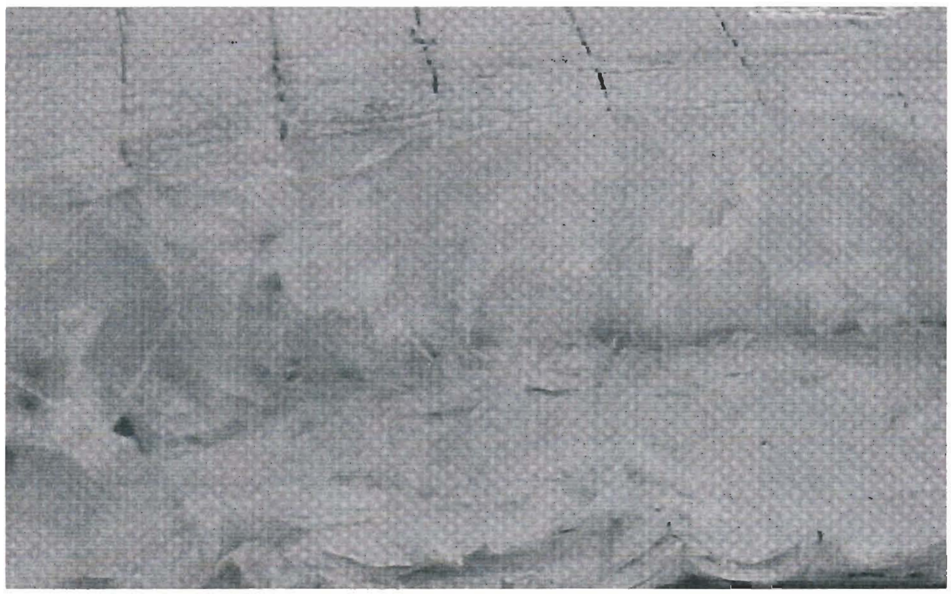

Figure 3. Layer of cotton "pulled back" for sampling.

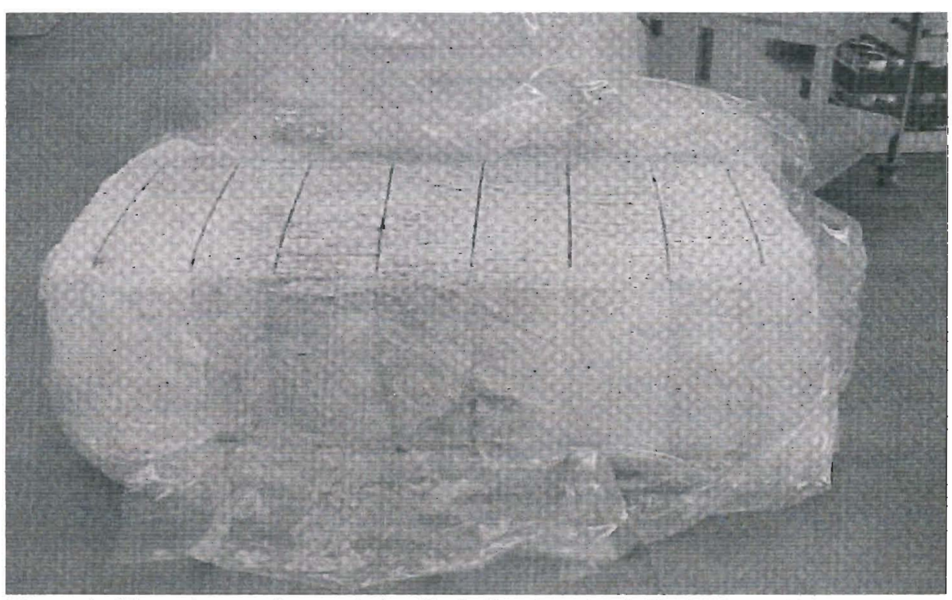

Figure 4. Water damage for one bale. Dark discoloration indicates organism growth as a result of high moisture storage condition.

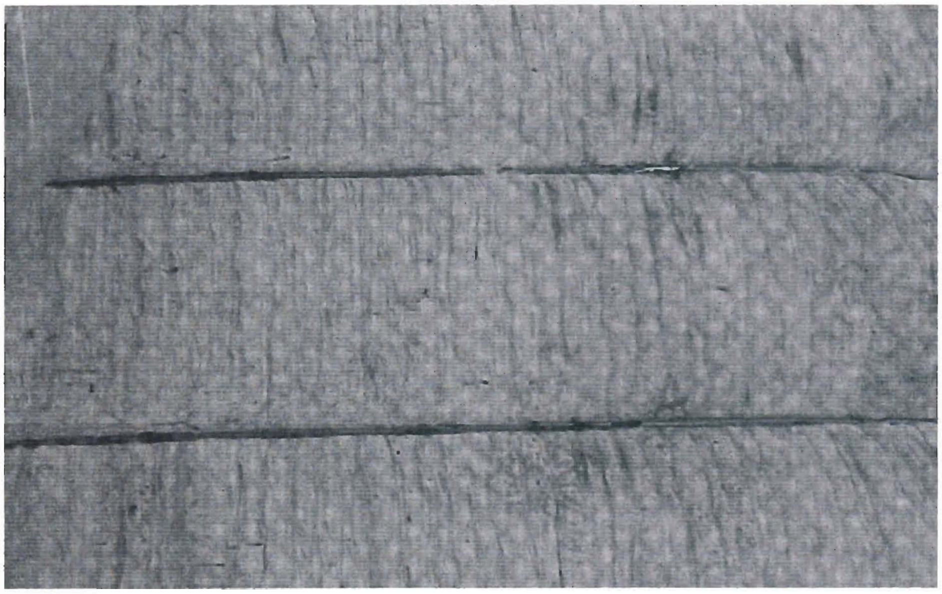

Figure 5. Water damage for bale with 48 pounds of water added (level 4, 11.9%).

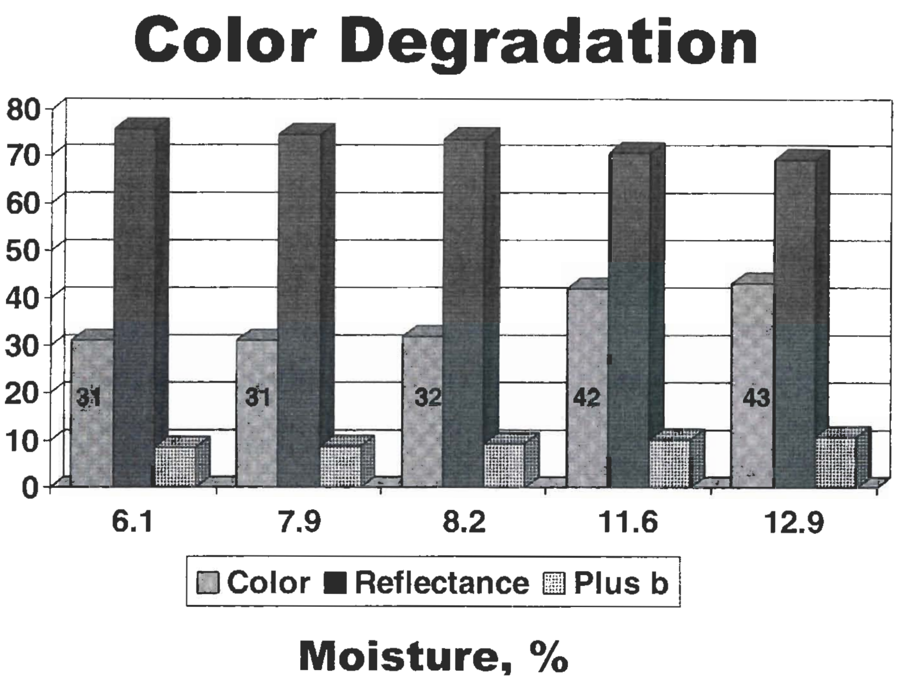

Figure 6. Impact of moisture on cotton color during bale storage for 116 days.