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MICROBIAL ACTIVITY OF STORED COTTON BALES THAT HAD BEEN BALED AT DIFFERENT MOISTURE LEVELS

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Abstract

The microbial effects and the effects on fiber quality of stored cotton bales that had been treated with moderate amounts of excess moisture were examined. The target moisture contents were 10%, 8%, 6% and a non-treated control bale. The actual initial moisture content were 9.5%, 8.0%, 5.4% and 5.0%, respectively. When the bales were opened for sampling, the control and low-level moisture treatment bales gained moisture while the high-level moisture treated bales lost moisture. The bale moisture content tended to equilibrate to between 6% and 7% during storage so a lower weight bale would most likely be delivered to the end user with the higher moisture treated bales. No practical differences were observed for cotton dust potential, or fiber quality, especially in regards to color grade, reflectance or yellowness, resulted from the different water treatments. Differences in microbial activity indicated lower viable populations with increasing moisture contents, but this was expected and did not appear to have any practical significance, which was borne out by the lack of differences in fiber quality.

Introduction

The practice of adding water to ginned cotton to reduce bale packaging forces and increase the bale weight to make up for excessively dry cotton resulting from ginning has sometimes been extended to increase profitability. When excess moisture is added and the bales stored at higher than recommended moisture levels, microbial activity can be stimulated to such an extent that fiber quality decreases during storage and mold activity may increase to become an unnecessary health risk (Chun and Anthony, 2002; Lalor et al., 1994). However, if more moderate moisture levels and storage conditions where the microbial activity is not stimulated excessively, perhaps the advantages of reducing excess bale packaging forces, of making up some of the moisture lost during ginning (Anthony and Griffin, Jr., 2001) and of providing the beneficial effects of moisture on fiber quality and processing as put forth by McAlister (1997), might be obtained at the same time so that the producer and end-user of the cotton would both gain advantages. This study looked at the fiber quality and microbial activity of cotton bales that had additional moisture added (a control bale where no additional moisture was added, and bales with targeted moisture levels of 6%, 8% and 10% moisture) and had been stored for approximately 1 year before opening.

Materials and Methods

Cotton and Moisture Treatment

Cotton was from the 2001 harvest year. The four bales used in this study were duplicate bales ginned in September 2001, from a study being conducted by ITT, which were sent to the Cotton Quality Research Station (CQRS) for microbial, and fiber quality and processing evaluation. Moisture treatments were added after ginning but before baling. The moisture treatments consisted of four target moisture levels: a control where no moisture was added, a 6% moisture level, a 8% moisture level and a 10% moisture level, percent moisture based on the oven dry method. The bales were protected with a single polypropylene sheet wrap bound around the bales by six plastic straps. The bales were stored for approximately one year: approximately six months under warehouse condition before being shipped to CQRS where the bales were held in the pilot plant under processing plant conditions (23.9 ºC and 55% RH) until opened.

On August 20, 2002, the bales were opened and samples taken for fiber quality, microbial and dust potential assays. The bales were laid on the floor of the pilot plant so that the cotton compression layers were parallel with the floor. Each bale was divided into 10 equal zone layers going from the top of the bale to the bottom. From the inside surface of each zone, 10 samples were removed along a diagonal of each zone/layer.

Statistical Analysis

Of the 100 samples from each bale, 40 samples were randomly chosen for dust and microbial assays: eight samples were randomly chosen from the 20 samples from each two adjoining zone pairs (zones 1 & 2; 3& 4; 5 & 6; 7 & 8; and 9 & 10). The pooled samples from the four bales were then randomly assigned sample identification numbers from 1 to 160 and the samples assayed sequentially. A completely randomized split block design was used. A $\log_{10}$(cfu+1), where cfu = microbial population as colony forming units per gram lint (corrected for dry weight), transformation was used for the analysis dealing with the microbial data.

Data were analyzed using release 8.00 or earlier releases of SAS (SAS, Statistical Analysis System; SAS system for Windows version 4.90.3000, SAS Institute Inc., Cary, NC, USA) for making mean comparisons. Otherwise, additional testing and data manipulation was done with Microsoft EXCEL 2000 or earlier releases of EXCEL (Microsoft Corporation, USA).

Cotton Dust Potential

A Microdust and Trash Monitor (MTM) was used to determine cotton dust potential (Millner et al., 1988; Sasser et al., 1986) as described by Chun and Perkins (1996). The Testing Laboratory at CQRS performed the cotton dust potential assay; for each sample, 20-gm portions were assayed and the dust from each sample was collected on six polyvinyl chloride filters (Pall Gelman Sciences, Ann Arbor, MI: GLA-5000 Membrane, 5-μm 37 mm, PVC membrane filter). Cotton dust potential is reported as the total cotton dust per 20-gm samples.

Microbial Activity and Fiber Quality

Determining the extent of biological degradation in each moisture treatment consisted of measuring the viable microbial populations (total and Gram-negative bacteria, and total fungi). Changes to the physical properties of the fiber were measured by the Advanced Fiber Information System (AFIS) and by the High Volume Instrument (HVI) cotton classification analysis. The samples were tested on site at CQRS for the AFIS measurements, and the samples were sent to the USDA-AMS Cotton Division Classing Office in Memphis, TN, for HVI analysis. The microbial assays used 1-gram of lint from each sample for total bacterial and total Gram-negative bacterial populations using the method described by Chun and Perkins (1996); for fungal populations, the method described by Chun and McDonald (1987) was used. However, because of the size of the study, incubation was made at room temperature, 20°±2° C for 3 days for the total bacterial and Gram-negative bacterial assays, and for 7 days for the fungal population assay.

Results and Discussion

The actual amounts of moistures applied to the bales differed slightly from the target values of 6%, 8 % and 10%; 5.4%, 8.0 and 9.5%, respectively (Table 1). The control or 'normal' bale had an initial moisture content of 5.0%. At the end of storage, the normal and 6% treatment bales gained 0.7% and 0.6% moisture, respectively; and the two high moisture treatments, 8% and 10%, lost 1.2% and 2.3% moisture, respectively. The moisture content and weight of bales may increase or decrease during storage while the cotton equilibrates with the storage environment (Anthony and Herber, 1991) so these changes were not unexpected and mirror the changes observed by Chun and Anthony (2002). However, these bales were stored with just a single polypropylene sheet wrap and started with lower levels of added moisture than the bales studied by Chun and Anthony (2002); so even though these bales were stored for a longer period, these bales probably equilibrated to 'safe' storage moisture levels (Hall and Elting, 1951) earlier during the storage period. Negligible loss of fiber quality was observed (Table 2 and 3). Selected AFIS measurements of the card mat, card sliver and finisher sliver of the treated bales showed some significant differences between treatments; however, these differences are very small and do not appear to reflect practical differences in fiber quality (Table 1). This was particularly clear when most of these differences showed poor association with increased moisture content.

HVI measurements did not show poorer fiber qualities resulting from being treated with added moisture (Table 3). The important reflectance and yellowness did not appear to be degraded by graying or becoming significantly more yellow by added moisture. Only with the highest moisture treatment, 10% moisture treatment, was a small deterioration in color observed which was reflected in a small change in color grade. The beneficial effects of moisture on fiber quality and processing as put forth by McAlister (1997) would not be expected to be realized since no significant improvement with fiber quality was observed either – mike, maturity ratio, fiber index and strength showed no significant or noticeable improvement with added moisture.

Generally, higher dust potential has been associated with higher levels of microbial activity. But in this study, the dust potential did not significantly increase or decrease with added moisture even though the two higher moisture levels tended to have significantly lower viable total bacterial, Gram-negative bacterial and fungal population densities. While higher moisture levels are generally associated with higher microbial levels, the lower populations probably represent a die off situation of the populations by the early moisture stimulation. The initial early higher moisture content probably broke the dormancy survival stage causing short-term high microbial activity. Later when the cotton equilibrated with the storage environment, the moisture content dropped below levels that would sustain growth and caused die-off, leaving a lower number of viable bacteria and fungi to be assayed (Table 1). This is in contrast to the observation made earlier by Chun and Anthony (2002) where the moisture content remained high enough through storage to sustain fungal growth and resulted in a significantly higher fungal density (Chun and Anthony, 2002; Hall and Elting, 1951).

In this study, the cottons attempted to equilibrate with its storage conditions to reach moistures of about 6% to 7% during storage. The added moisture did not appear to have caused the cottons to suffer from microbial activity, which was supported by the failure to observe significant fiber quality deterioration, to observe increased dust potential, or to observed increased viable microbial populations, associated with the increased moisture. On the other hand, the fiber quality did not improve with increased moisture either, to suggest that added moisture before baling would not replace laydown conditioning to improve fiber quality and processing as put forth by McAlister (1997). Reduction of bale packaging forces and increased bale weight might be the main advantage of adding water; but the level of water treatment which would prove the most advantageous is perilously close to the levels where fiber quality deterioration and increased microbial activity (Chun and Anthony, 2002) might occur and which might offset the small profit from adding additional water to increase bale weight.

Disclaimer

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Table 1. Target moisture treatment, actual initial moisture content and final moisture content after approximately 1 year storage.

Treatment/Target Moisture, %	Actual Initial Treatment Moisture, %	Final Treatment Moisture After Storage, %
Normal	5.0	5.7
6	5.4	6.0
8	8.0	6.8
10	9.5	7.2

Table 2. Advanced Fiber Information System[1] of water treated bales.

	Treatment/Target Moisture[2], %	Uqlw[2], in.	Sfcw[2], %.	Matratio[2] %	Nep counts/ gram[2]	VFM[2], gm
CARD MAT	Normal	1.06^{B}	11.4^{A}	0.92^{BC}	325^{A}	0.76^{B}
	6	1.05^{B}	10.8^{BA}	0.93^{BA}	302^{A}	1.04^{A}
	8	1.08^{A}	10.6^{B}	0.94^{A}	311^{A}	0.88^{BA}
	10	1.06^{B}	9.8^{C}	0.91^{C}	308^{A}	1.07^{A}
	Treatment/Target Moisture[2], %	**Uqlw[2], in.**	**Sfcw[2], %.**	**Matratio[2] %**	**Nep counts/ gram[2]**	**VFM[2], gm**
CARD SLIVER	Normal	1.07^{B}	10.3^{A}	0.96^{A}	45^{A}	0.22^{A}
	6	1.08^{A}	9.8^{BA}	0.95^{B}	46^{A}	0.22^{A}
	8	1.09^{A}	9.2^{B}	0.95^{B}	50^{A}	0.20^{A}
	10	1.09^{A}	9.0^{B}	0.94^{B}	47^{A}	0.24^{A}
	Treatment/Target Moisture[2], %	**Uqlw[2], in.**	**Sfcw[2], %.**	**Matratio[2] %**	**Nep counts/ gram[2]**	**VFM[2], gm**
FINISHER SLIVER	Normal	1.11^{B}	10.6^{A}	1.00^{A}	38^{A}	0.23^{A}
	6	1.10^{B}	10.9^{A}	1.00^{A}	35^{A}	0.32^{A}
	8	1.12^{A}	8.9^{A}	1.00^{A}	36^{A}	0.30^{A}
	10	1.11^{B}	9.7^{A}	0.99^{A}	44^{A}	0.25^{A}

[1]Uqlw=upper quartile by weight in inches; Sfcw=short fiber content by weight; Matratio=percent maturity ratio; VFM=visible foreign matter.

[2]Mean separation within column by Duncan's multiple range test, 5% level. Means with the same letter are not significantly different.

Table 3. Average HVI data.

Treatment/ Target Moisture, %	September, 2001 USDA HVI			September, 2002 USDA HVI					
	Color Grade	Reflectance, Rd (%)	Yellowness +B	Color Grade	Reflectance, Rd (%)	Yellowness, +B	Mike	Strength g/tex	Short Fiber Index
Normal	31	76.0	9.1	31	76.0	9.0	5.28	28.20	10.15
6	31	76.0	9.0	31	76.0	9.3	5.30	27.95	10.20
8	31	76.0	9.0	31	75.8	9.2	5.30	28.20	10.33
10	31	77.0	9.2	32	74.8	9.6	5.33	28.20	10.48

Table 4. Overall cotton dust potential and average microbial population in treated bales.

Treatment/ Target Moisture, %	Average Dust[1], mg/20-g lint	Total Bacteria[1], Log_{10}(cfu+1)	G(-) Bacteria[1], Log_{10}(cfu+1)	Fungi[1], Log_{10}(cfu+1)
Normal	2.82^{A}	6.474^{A}	6.071^{A}	4.13^{A}
6	2.73^{A}	6.456^{A}	6.125^{A}	3.93^{A}
8	2.75^{A}	6.011^{B}	5.575^{B}	3.24^{C}
10	2.70^{A}	6.099^{B}	5.556^{B}	3.62^{B}

[1]Mean separation within column by Duncan's multiple range test, 5% level. Means with the same letter are not significantly different.