STUDY OF MOISTURE RESTORATION AT MIDSOUTH GINS IN 2003

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Abstract

Moisture restoration practices were surveyed in 20 gins in Mississippi and Arkansas in September-November 2003. The types of moisture restoration systems surveyed were: 1) lint slide grid, 2) humidified air at/near the battery condenser, 3) direct water spray at the lint slide, and 4) combinations of 1 and 3, or 2 and 3. For this survey, one sample was taken from each bale before moisture restoration and another one after moisture restoration for 25 consecutive bales of cotton on three or more different days at each gin during the season. Initial moisture contents averaged for individual gins ranged from 3.0 to 5.8%, and final moisture contents averaged for individual gins ranged from 3.6 to 7.3%. The simple average across all samples and gins for initial and final moisture contents was 4.4% and 5.4%; respectively, thus about 5 pounds of moisture was added per bale. Bales may be stored safely at moisture levels below 7.5%. However, 7.8% of the bales were above the National Cotton Council recommended storage moisture of 7.5%. Twelve of the 20 surveyed gins produced bales that exceeded the 7.5% recommended moisture level, most of these occurred at gins using the direct spray method (22.9%) of moisture restoration. These bales may experience color degradation during extended storage.

Introduction

After cotton bolls open, the fiber and cottonseed moisture continually seek to reach equilibrium with the changing atmosphere. Loose cotton fiber gives up moisture readily at low humidity but absorbs moisture much more slowly at high humidity. The moisture of the seed cotton at harvesting differs dramatically across the Cotton Belt due to the variation between humid and arid climates in the United States. In addition, the humidity before and during harvesting also influences the moisture of the lint, cottonseed and trash fractions of the seed cotton. After harvesting, the seed cotton is placed in modules or trailers and compacted. Published guidelines establish the upper limit for safe storage of seed cotton at 12% moisture content (Lalor, Willcutt and Curley, 1994). Seed cotton moisture is virtually impossible to determine accurately in the module; samples should be taken before moduling and oven-tested (ASTM, 1971). This technique is not done because of the time and expense involved. As an alternative, temperature measurements can be used to detect potential problems. Temperatures can be probed soon after the module is built and then collected for several days. If temperatures rise over 15°F, regardless of moisture content the moisture is too high and the module should be ginned immediately to avoid fiber quality degradation.

Most moisture sensors used at the 921 gins in the United States measure the moisture of the lint and ignore the moisture of the cottonseed. Reference to safe module storage in terms of seed cotton moisture and safe ginning moisture in terms of lint confuses farmers and ginners. For example, lint represents about 35% of the seed cotton mass and cottonseed represent about 58% with the remainder being trash. About 1,400 pounds of seed cotton is required to produce a 480-pound bale of lint and about 810 pounds of cottonseed. At the maximum safe storage level of 12% seed cotton moisture, the lint is about 9% moisture and the cottonseed about 13% moisture. This 12% upper limit for safe storage of seed cotton assumes that the cotton is not compressed excessively or enclosed in an impermeable material that restricts the ability of the cotton to "breathe". In other words, the moisture must be able to escape to the drier air surrounding the module as the seed cotton equilibrates with the environment. Most seed cotton is moduled at moisture contents significantly below 12%. At more typical moistures of 8 to 10% seed cotton moisture, the lint is 6 to 7%. It is not uncommon, however, for lint to enter the gin system at less than 5% moisture content; this cotton may be dried further by the conveyance air.

After the seed cotton in the module equilibrates with the environment, ginning operations usually proceed more smoothly. Cotton is dried at gins in order to increase cleaning efficiency of machines and to improve the appearance of the cotton fiber. The Cotton Ginner's Handbook (1994) recommends maximum fiber moisture at ginning of 7%. The Handbook does not give the safe storage moisture content for lint in universal density bales. After cotton fiber is baled, moisture transfer occurs very slowly, especially at high densities. In fact, bales at densities of 12 lb/ft3 required over 60 days to equilibrate with the environment, while bales at 28 lb/ft3 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 during storage. 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).

Ginners often add moisture at the lint slide to reduce bale-packaging forces and to recover some of 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% moisture to a bale but the direct spray approach can add far more. Most ginners believe that they add 5 to 15 pounds of water per bale with their moisture restoration systems. Anthony (2002a, 2002b and 2003a) evaluated the impact of spraying moisture on cotton fiber quality at the lint slide in three studies. In these studies, water was sprayed on cotton lint as it came down the lint slide, and the resulting bales were packaged at universal density in 1) polyethylene, 2) strip-laminated woven polypropylene, and 3) fully coated woven polypropylene bags and stored for several months. Across the three studies, color was reduced for the bales initially above 8% moisture content. The grayness and yellowness were negatively impacted at moisture levels as low as 7.3%. As a result of these findings, ginners were cautioned against applying excessive moisture to cotton before long-term storage and noted that bales should be stored below 8% moisture content, wet basis, regardless of the permeability of the bale covering materials in order to avoid color degradation.

Anthony (2003b) surveyed moisture restoration practices in 18 gins in Mississippi and Arkansas in October and November 2002. The types of moisture restoration systems surveyed were: 1) lint slide grid, 2) humidified air at/near the battery condenser, 3) direct water spray at the lint slide, and 4) combination of 2 and 3. One sample was taken from each bale before moisture restoration and after moisture restoration for 25 consecutive bales of cotton on three or more different days during the season. Initial moisture contents averaged for individual gins ranged from 3.7 to 6.2%, and final moisture contents averaged for individual gins ranged from 4.2 to 7.7%. The simple average across all samples and gins for initial and final moisture contents was 5.1% and 6.2%, respectively, thus about 5.5 pounds of moisture was added per bale. Moisture was over 8% in 8.6% of the bales. Ten of the 18 surveyed gins produced bales that exceeded the 8.0%, mostly those using the direct spray or combination methods of moisture restoration. These bales may experience color degradation during extended storage.

The Quality Task Force of the National Cotton Council recommends that bales not be packaged at moistures above 7.5% (wet basis) in order to avoid the possibility of fiber quality degradation (National Cotton Council, 2003). The purposes of this survey were 1) to determine the amount of moisture added to cotton at the lint slide in gins in the Midsouth using commercially available moisture restoration systems, and 2) to determine the number of bales packaged above 7.5% moisture.

Procedure

Twenty gins in Mississippi and Arkansas cooperated in the survey during the ginning season in September to November 2003. The moisture restoration systems in this survey were: 1) lint slide grid, 2) humidified air at/near the condenser, 3) direct water spray at the lint slide, and 4) combinations of 1 and 3, or 2 and 3. For the first type system, most of the gins used the lint slide grid by Samuel Jackson or CIMCO. For the second type, most gins used either the Steamroller by Samuel Jackson or the Moisture Conditioner/"Hot Lips" by Lummus. The Lewis Cotton Moisture System was used for the third type although other direct-spray systems such as the Hurdst Hydromist are used. The fourth type consisted of the Lewis or Uster spray systems in combination with either the grid or humid air system. Additional information can be obtained from the manufacturers.

For this survey, one sample was taken from each bale before moisture restoration and another one after moisture restoration for 25 consecutive bales of cotton on three or more different days during the season for a total of 150 samples per gin. The "before" sample was taken after the gin stand and before the battery condenser, and the "after" sample was taken from the same area as the class sample on the outside of the bale. The moisture samples were placed in sealed metal cans for 4 to 6 days before analyses by the oven method (ASTM, 1971). The lint was allowed to remain in the cans longer than usual in order to allow the fiber to equilibrate in the can, especially in the case where the water was sprayed directly on the top of the batt. In some cases, the "after" moisture was lower than the "before" moisture; however, all data points were used.

Results

An unusually good harvest season with little rain occurred during the September to November 2003 timeframe when the study was conducted. The average moisture before and after moisture restoration for all the samples taken at each gin are shown in Table 1 as well as standard deviations at each gin. The percentage of bales at various moisture levels before moisture restoration is shown in Figure 1 with the majority of the bales (75.4%) in the 3 to 5% moisture range (wet basis). Initial moisture contents averaged for individual gins ranged from 3.0 to 5.8% (Table 1). After moisture restoration, the majority of the bales (74.9%) shifted to the 4 to 6% moisture range (Figure 2). The moisture distribution for all three days is shown in Figure 3 for one gin. About 24% of the bales at that gin were above 8% moisture content. Final moisture contents averaged for individual gins ranged from 3.6 to 7.3% (Table 1). The simple average across all samples and gins for initial and final moisture contents was 4.4% and 5.4%, respectively.

Data in Table 1 is grouped together by the type of moisture restoration system. On average the final moisture contents were well within a safe range; however, the high maximum values suggest a possible problem at 12 of the surveyed gins since bale moistures exceeded 7.5% on one or more occasion.

The average pounds of moisture added to the lint at each gin was calculated by subtracting the initial moisture from the final moisture and multiplying times the bale weight (i.e. 0.07 – 0.06 times 500= 5) are shown in Table 1, and ranged from 1.4 to 12.0 pounds. The average across all bales was 4.6 pounds. The percentage of bales that exceeded 7.5% moisture content at each gin is also shown in Table 1 and ranged from 0 to 48%. Across the entire survey, 7.8% of the bales exceeded 7.5% moisture. The percentage of bales that exceeded 8% in 2002 was 8.6% as compared to 4.7% in 2003. The bales in the "exceeds 7.5% category" will likely experience discoloration during storage.

Most gins (15 of 20) over dried the cotton as indicated by the moisture contents below 5% before moisture restoration. Ten gins even dried the cotton to moistures below 4%. Under low relative humidity and dry conditions in the Midsouth, moisture contents of about 5% are not unusual. Additional drying at the gin reduces the moisture levels sufficiently to cause a measurable reduction in staple length due to fiber breakage during gin processing.

Data averaged across each type of moisture restoration system are presented in Table 2 along with the standard deviation for each type system. The standard deviation ranged from 2.6 pounds for the grid system to 8.8 pounds for the spray system suggesting the need for more uniform application of the moisture as well as better control of the restoration process. Note that the standard deviation is an indication of the variation in the amount of moisture added to each bale as well as variations due to the sampling protocol. When the data for each measurement day was considered individually, the variation in moisture added was also much greater for the spray system than for the other types. Standard deviations were as low as 0.8 pounds for one system on one day to as high as 16.4 pounds for another system. Additionally, the percentage of bales above 7.5% was 0.4, 0.7, 22.9, and 1.7% for the Grid, Humid, Spray, and Combo systems, respectively. Gins with higher standard deviations in final moisture also had a higher percentage of bales above 7.5%.

Conclusions

Gins with moisture restoration systems at the lint slide add about pounds of water per bale. Some bales (7.8%) were packaged at 7.5% or higher moisture content and may experience color degradation during storage. Since substantial variations occurred in the moisture added within each consecutive 25-bale group, additional control and management oversight is needed in order to ensure uniform moisture restoration and avoid bales with excess moisture. Improved moisture management is needed to control initial drying as well as moisture restoration.

Disclaimer

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Table 1. Initial and final moisture for multiple bales of cotton at 20 gins, averaged for about 25 bales monitored on three or more occasions. Note that data was not used when the "after" moisture was less than the "before" moisture.

Gin number	Type[1]	Pounds added per bale	Moisture before restoration, %	Moisture after restoration, %: Average	Standard deviation	Percentage bales over 7.5%
A	Spray	9.0	5.3	7.1	2.0	28.0
B	Spray	5.1	5.5	6.5	1.2	16.9
C	Spray	7.3	5.8	7.3	1.3	48.0
D	Grid	2.8	3.0	3.6	0.5	0
E	Combo	1.7	4.5	4.9	0.5	0
F	Humid	1.4	4.2	4.5	0.3	0
G	Combo	3.1	4.6	5.2	1.0	1.3
H	Grid	2.7	4.8	5.3	0.4	0
I	Grid	1.6	4.6	4.9	0.6	1.3
J	Spray	12.0	4.2	6.6	1.5	22.7
K	Spray	3.2	5.3	6.0	0.9	4.0
L	Humid	2.0	4.4	4.8	0.7	0
M	Humid	3.7	4.1	4.9	0.4	0
N	Spray	2.9	4.0	4.6	1.3	1.1
O	Humid	4.2	3.9	4.8	0.8	0
P	Humid	6.9	4.0	5.4	0.6	1.3
Q	Humid	4.6	3.9	4.8	0.6	0
R	Spray	10.4	3.7	5.8	1.3	9.3
S	Humid	3.7	3.9	4.6	1.3	2.7
T	Combo	4.4	5.2	6.0	0.7	1.3

[1]Grid=slide grid, Humid=humidified air at/near the battery condenser, Spray=direct water spray at the lint slide, and Combo=combination of Grid, Humid and Spray.

Table 2. Water added for each type moisture restoration system, averaged for about 25 bales monitored on three or more occasions. Note that data was not used when the "after" moisture was less than the "before" moisture.

Type moisture restoration system[1]	Percentage of bales above 7.5%	Water added, pounds: Mean, pounds	Standard deviation
Grid	0.4	2.4	2.6
Humid	0.7	3.8	4.2
Spray	22.9	7.0	8.8
Combo	1.7	3.3	3.7

[1]Grid=slide grid, Humid=humidified air at/near the battery condenser, Spray=direct water spray at the lint slide, and Combo=combination of Humid and Spray.

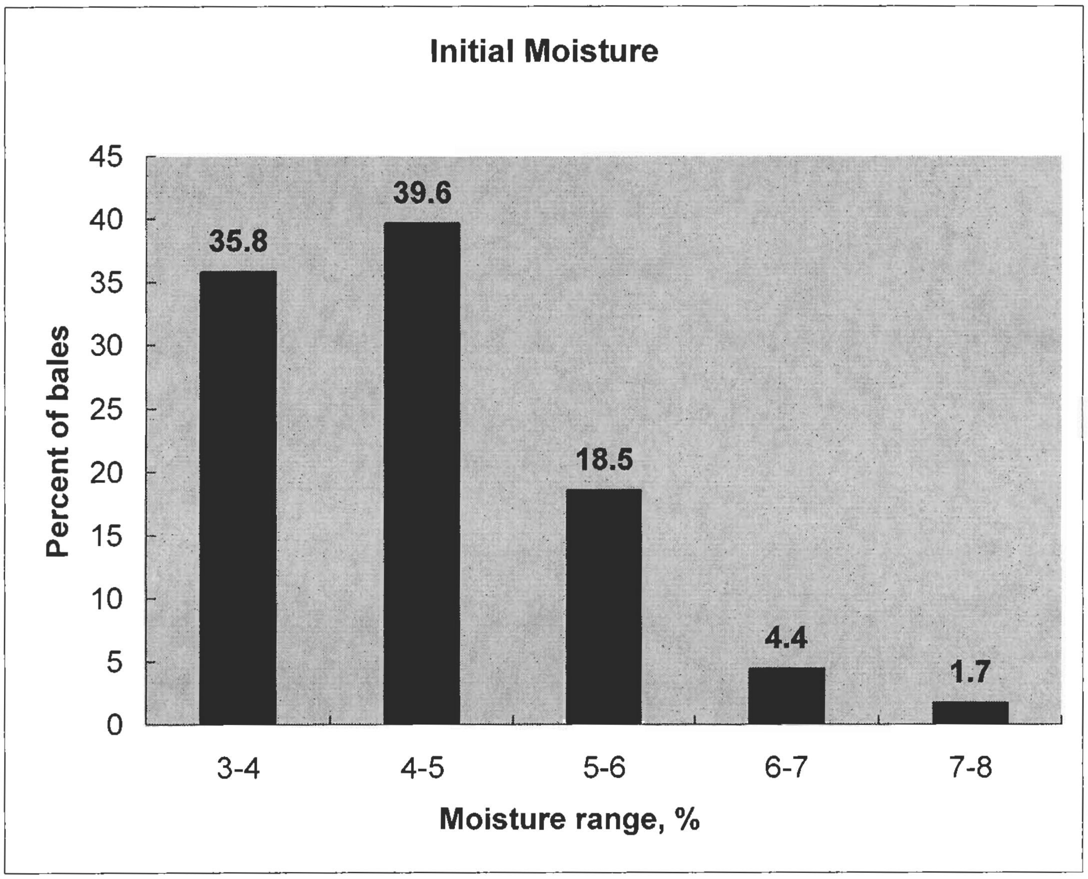

Figure 1. Frequency distribution for initial moisture for all gins in the survey.

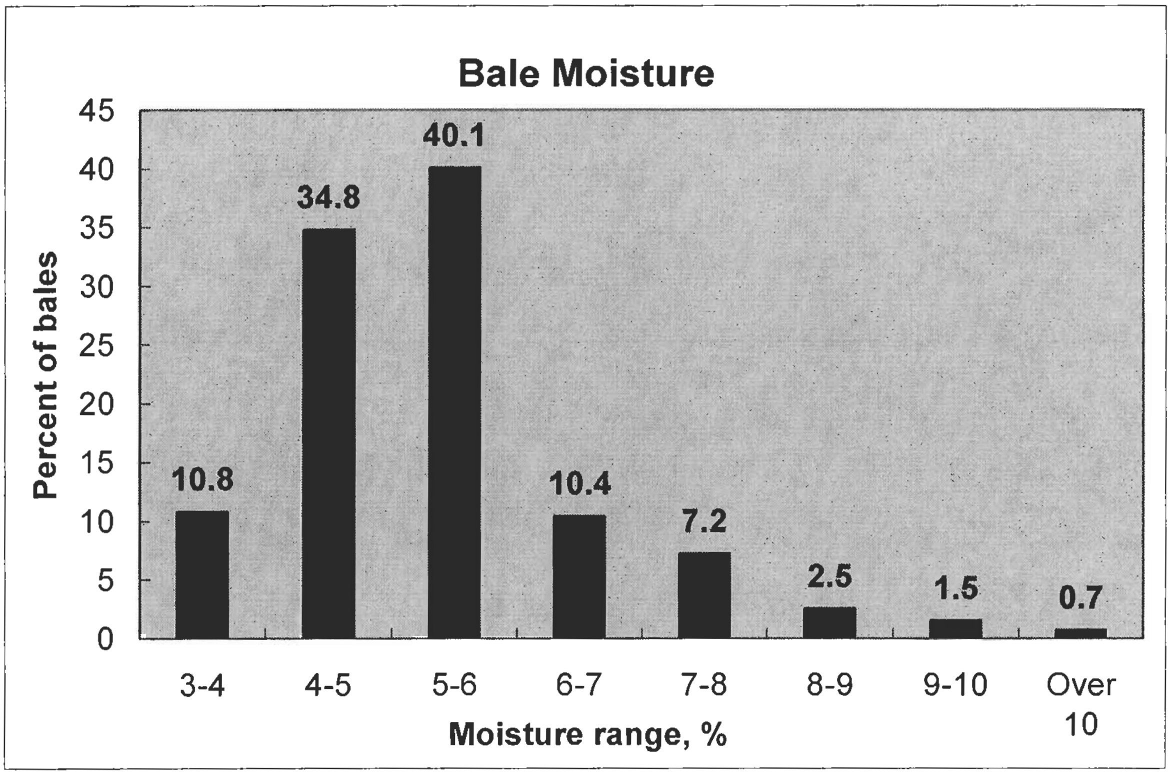

Figure 2. Frequency distribution for moisture content of bales after moisture restoration for all gins in the survey.

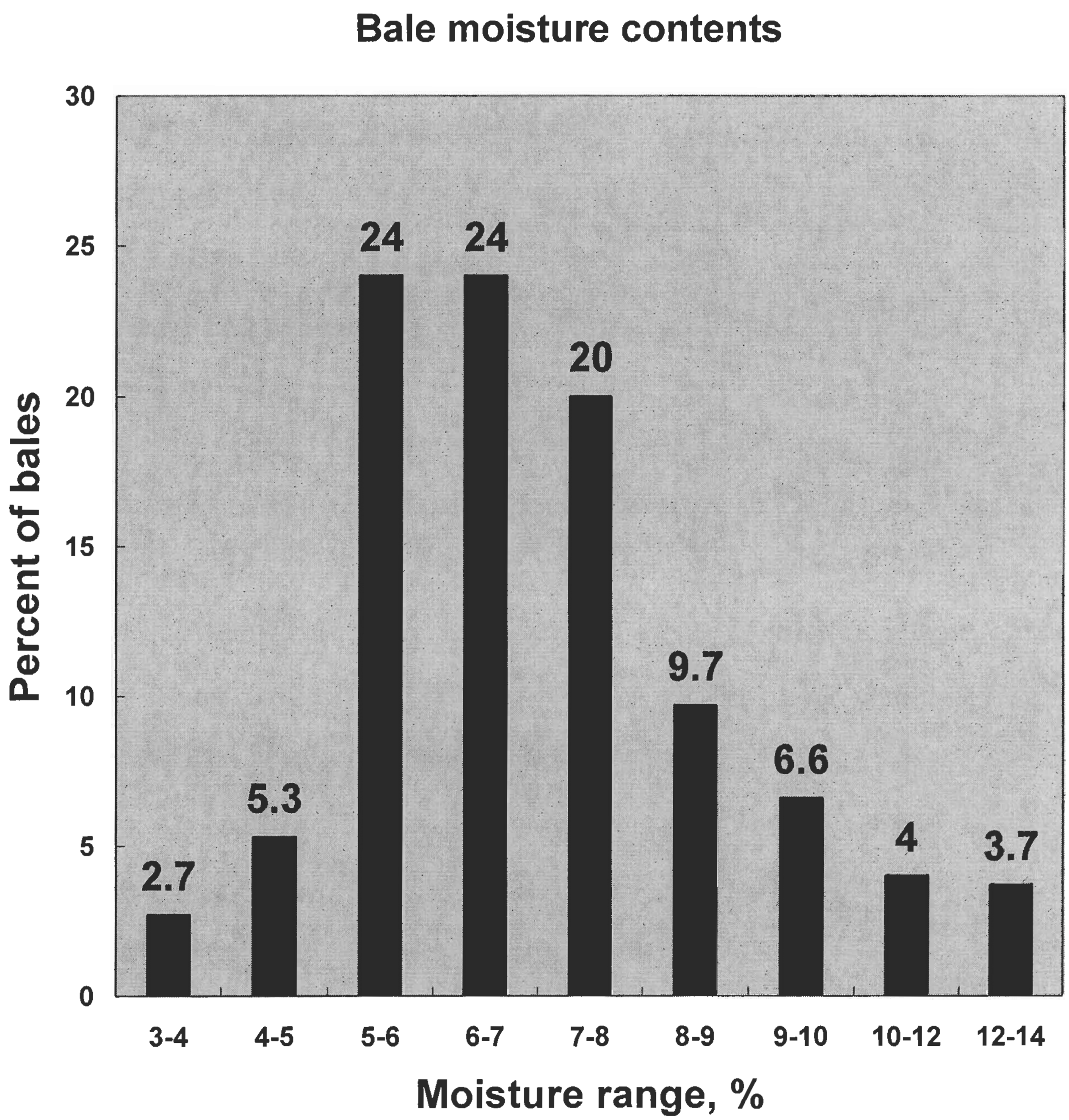

Figure 3. Frequency distribution of bale moisture after restoration for one gin using direct spray.