Moisture Restoration to Cotton at the Gin: Effects on Fiber and Spinning Properties

Marketing Research Report No. 708

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

CONTENTS

SUMMARY

This study illustrated that fiber moisture restoration gives good protection against certain losses of fiber properties attributable to severe drying. However, the combination of severe drying followed by the restoration of moisture is considered to be a less satisfactory practice than that of drying cotton to its proper moisture level through adequate controls. If the latter is done, restoration of moisture is not necessary. The proper function of restoring moisture at the gin is to raise the moisture level of cotton that was brought to the gin too dry for proper ginning.

Washington, D.C. Issued August 1965

Moisture Restoration to Cotton at the Gin: Effects on Fiber and Spinning Properties

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INTRODUCTION

The increased use of mechanical harvesters and the trend toward rough hand harvesting of cotton have resulted in increased drying and cleaning of seed cotton at gins in order to maintain high grades. The increased emphasis on drying often results in fiber-seed separation at low fiber moisture levels. This causes losses in inherent fiber properties and increased production difficulties in spinning.

Early studies of moisture restoration at gins showed that fiber qualities were definitely improved as a result of increasing the fiber moisture content of dry cotton before it reached the gin stand. However, experimental methods of restoring moisture to cotton were not, at that time, applicable to gins.[1] When studies showed that moisture restoration could be made an integral part of the ginning process, manufacturers of equipment developed commercial applications of the idea.

EXPERIMENTAL PROCEDURE

The objective of this study was to establish the merit of commercial methods that are available and can be used at the gin for restoring moisture to seed cotton after it has been dried and passed through overhead cleaning equipment but before it is ginned and the lint cleaned. The moisture restoration and ginning phases of this study were conducted during the 1961 and 1962 crop years at the U.S. Cotton Ginning Research Laboratory, Stoneville, Miss.

Two methods of restoring moisture to cotton were used:

1. *Vapor method.* A vapor phase restoration unit delivered humid air to the extractor-feeders where the air mixed with cotton to enable fibers to absorb moisture. This unit was operated concurrently with ginning and required no special routing of the cotton.

2. *Spray method.* Cotton fell through a mist of water, which was absorbed by or dispersed in the cotton before it was ginned. This method required that dried cotton be routed to the spray unit and then held in bale-size lots for about 20 minutes after spraying before cotton was further processed and ginned.

Thirty-three test bales from the 1961 and 1962 crops were processed during which cotton was subjected to no drying, light drying, and heavy drying. Moisture was restored through use of the vapor and spray methods after drying and cleaning of the seed cotton.

Electric moisture meters were used to help maintain target moisture levels while cotton was being ginned. These meters provided a quick way of estimating fiber moisture levels before and after drying. Moisture levels actually attained were determined by oven tests of canned samples collected at the feeder apron and lint slide. Samples were also taken to determine the amount of trash in lint, classification of lint, and spinning properties.

1961 Crop Experiments

The 1961 moisture-restoration and ginning experiments consisted of seven treatments carried out in three replications on Stoneville 7 variety of cotton. Cotton was harvested by use of a spindle picker on October 23 after the field had been defoliated about October 5.

Gin machinery and its sequence was as follows: Tower drier, 6-cylinder cleaner, bur machine, tower drier, 7-cylinder cleaner, extractor-feeder, gin stand, and 2 lint cleaners (fig. 1). Each test lot was large enough to yield 300 pounds of lint for spinning.

[1] Griffin, A. C., and Mangialardi, G. J. AUTOMATIC CONTROL OF SEED COTTON DRYING AT COTTON GINS—A REVIEW OF RESEARCH. U.S. Dept. Agr. ARS 42-57. 1961.

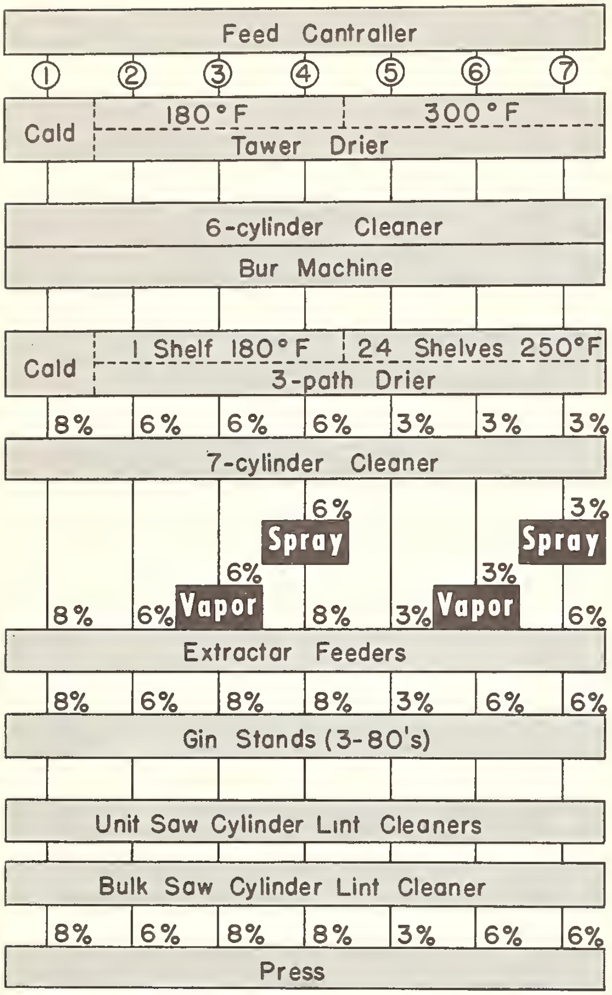

FIGURE 1.—Processing plan used in the cotton moisture-restoration study—crop of 1961.

The schedules of drying, restoring moisture, and the target moisture at ginning, by treatments were:

1. No drying; 8 percent at ginning.
2. Light drying; no moisture restoration; 6 percent at ginning.
3. Light drying; vapor phase restoration; 8 percent at ginning.
4. Light drying; liquid phase (spray) restoration; 8 percent at ginning.
5. Heavy drying; no moisture restoration; 3 percent at ginning.
6. Heavy drying; vapor phase restoration; 6 percent at ginning.
7. Heavy drying; liquid phase (spray) restoration; 6 percent at ginning.

Tests showed that cotton required only 4½ seconds to pass through the extractor-feeder. This short exposure to moisture limited the quantity of moisture that the cotton could absorb by this method and resulted in departures from target moistures levels. The spray unit had five misting nozzles that discharged water at a rate of 2.8 pounds (0.34 of a gallon) per minute.

1962 Crop Experiments

The 1962 crop experiments consisted of four treatments that were performed in three replications on Stoneville 7A variety of cotton. The cotton had been defoliated prior to mechanical picking on October 3 and 4. It was ginned on October 4 and 5. Test lot sizes were large enough to yield 300 pounds of lint for spinning. Ginning was performed at the battery maximum rate—4 bales per hour.

The sequence of gin machinery used in the 1962 test was: Tower drier, 6-cylinder screen cleaner, bur machine, tower drier, 7-cylinder cleaner, extractor-feeder, 79-saw gin stand, and 2 stages of lint cleaning (fig. 2). Moisture was restored by use of the same vapor and spray methods that were used in the 1961 tests.

The schedules of drying, restoring moisture, and the target moisture at ginning by treatments were as follows:

1. No drying; 6 percent at ginning.
2. Drying to low moisture; no restoration; 3 percent at ginning.
3. Drying to low moisture; vapor restoration; 6 percent at ginning.
4. Drying to low moisture; spray restoration; 6 percent at ginning.

During the 1962 tests, the exposure period of seed cotton to vapor within the extractor-feeder was only 1 second. This reduction in exposure from the 1961 tests was due to a change in the type of extractor-feeder in the gin. Humid air was supplied to the extractor-feeder at a temperature of 110° F. and a relative humidity of 85 percent. More moisture was applied by the spray technique in 1962 than in 1961. In 1962 the spray apparatus consisted of 13 nozzles, discharging water at a rate of 7.3 pounds (0.85 of a gallon) per minute.

EXPERIMENTAL RESULTS

Moisture content, trash content, lint classification, fiber length distribution, fiber strength, nep count, yarn properties, and ends down are shown in tables 1, 2, 3, 4, and 5.

Micronaire values for cotton used for the 2-year study ranged from 4.6 to 4.9. No significant differences existed between treatments.

Moisture Restored

In both years more moisture was added to and retained by cotton through use of the spray method than by the vapor method (table 1). However, this is obviously due to the number of misting

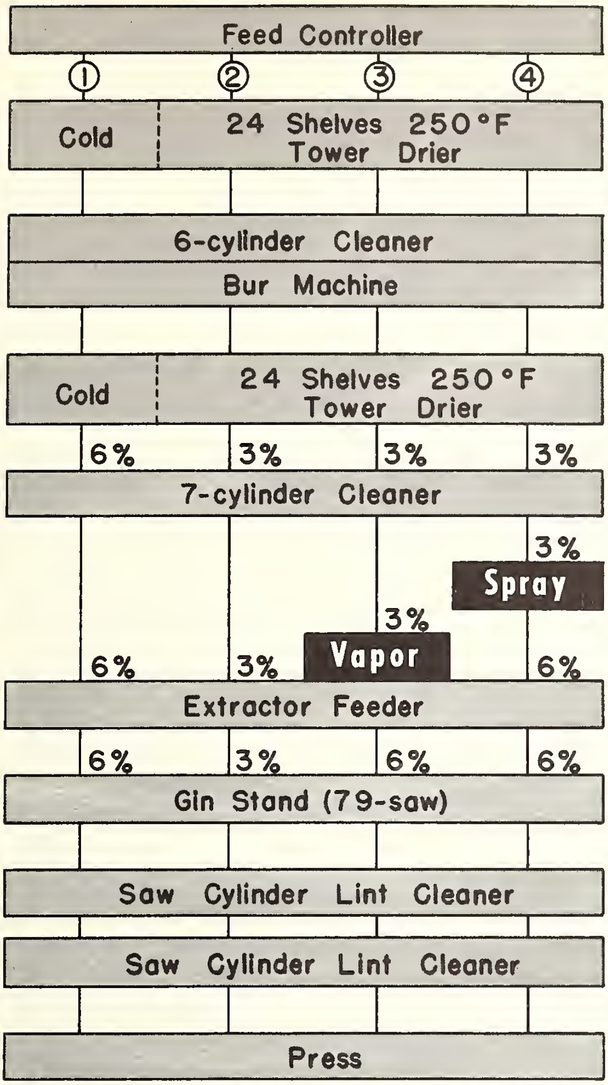

Figure 2.—Processing plan for cotton moisture-restoration study—crop of 1962.

nozzles used and the time cotton was exposed to vapor. The exposure time and mixing required for satisfactory absorption or dispersions of spray-added moisture depend mainly on the quantity of moisture applied. Both systems are suitable for restoring moisture to cotton at the gin if dispersion and absorption times are properly controlled. The quantity of moisture restored by the vapor phase system can be increased by lengthening the exposure period. A vapor phase restoration system equipped with a special delay chamber that lengthens the exposure period is now commercially available.

In the 1961 study, the vapor method increased the fiber moisture content of the lightly dried and heavily dried lots from 5.1 to 6.3 percent (1.2 percentage points) and from 4.9 to 5.6 percent (0.7 of a percentage point), respectively (table 1). The spray method increased the fiber moisture content of similarly dried cotton from 5.1 to 7.3 percent (2.2 percentage points) and from 4.9 to 6.2 (1.3 percentage points), respectively.

In 1962, the vapor treatment increased the fiber moisture content from 2.7 to 3.6 percent and the spray treatment increased it to 8.1 percent at the feeder apron.

For most treatments, the moisture content of cotton at the feeder apron sampling location is fairly representative of the moisture content at time of ginning because air in the doffing and transport systems caused considerable loss of moisture through evaporation. It should be mentioned that samples obtained at the feeder apron for fiber moisture analysis were saw ginned and that some drying occurred during the ginning of samples. It is believed that the fiber moisture present at ginning following its restoration by either method, particularly the vapor method, was actually greater than is reported.

Trash Content and Lint Classification

The study showed a general decrease in lint grade index due to moisture restoration after drying (table 1). However, the decrease was not enough to change the grade designation following restoration by either the vapor or spray method. A grade change noted for the spray method in the 1962 study was attributed to uneven distribution of a large quantity of moisture, indicating that the addition of too much moisture could give rough preparation. Lint grades for lots that had been dried were in the Middling and Middling Plus range compared with SLM and SLM Plus for lots that had not been dried. No significant differences in picker and card waste either year were attributed to treatments.

Fiber Length Distribution

Suter-Webb array and fibrograph data from ginned lint reflected increases in fiber length that were due to moisture restoration after drying (table 2). Significant increases in upper quartile length and mean length attributed to moisture restoration were accompanied by lower coefficients of length variation and fewer fibers shorter than one-half inch. The effects of fiber moisture on mean length and on percentage of fibers shorter than one-half inch are shown in figures 3 and 4.

The correlation of fiber mean length and percentage of fibers shorter than one-half inch to fiber moisture at ginning, when lint was undried, dried, and moisture-restoration treatments are lumped, are fairly good and indicate that moisture content at ginning is a highly important factor in controlling fiber damage during ginning.

TABLE 1.—*Moisture and trash content and lint classification of cotton given stated treatments—crops of 1961 and1962*

Treatment	Fiber moisture content			Trash Content				Lint classification		
	Initial	Feeder apron	Lint slide	Wagon	Ginned lint	Opening and picking waste	Picker and card waste	Grade		Staple length
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Index*	*Name*	*32d of an inch*
1961 crop:										
1. No drying	7.7	7.0	6.2	5.4	3.06	0.74	4.54	97.9	SLM	35.1
2. Light drying	7.1	5.1	4.3	5.3	2.47	.57	4.05	101.9	M	34.9
3. Light drying plus vapor	8.1	6.3	5.3	4.6	2.73	.69	4.17	99.9	M	35.0
4. Light drying plus spray	7.6	7.3	5.3	6.5	2.47	.63	4.03	101.5	M	35.0
5. Heavy drying	9.3	4.9	3.3	5.3	2.34	.58	4.16	102.6	M	35.0
6. Heavy drying plus vapor	9.0	5.6	3.6	5.3	2.15	.61	4.09	102.4	M	35.0
7. Heavy drying plus spray	9.3	6.2	5.0	4.1	2.48	.61	4.09	101.9	M	34.9
Analysis of variance [1]				NS	NS	NS	NS	NS		NS
1962 crop:										
1. No drying	7.4	6.2	5.7	6.7	2.91	.70	4.98	94.0	SLM	34.0
2. Heavy drying	7.3	2.7	2.8	6.5	2.19	.62	4.60	100.0	M	34.0
3. Heavy drying plus vapor	7.2	3.6	3.3	6.4	2.23	.57	4.60	100.0	M	34.0
4. Heavy drying plus spray	7.3	8.1	5.5	6.4	3.04	.73	4.98	95.0	SLM	34.0
Analysis of variance [1]				NS	**	*	NS	**		NS

[1] NS means not significant; * means significant at the 95-percent level; and ** means significant at the 99-percent level.

Table 2.—*Fiber length distribution and fiber strength of ginned lint for stated treatments—crops of 1961 and 1962*

Treatment	Fiber moisture content at feeder apron	Suter-Webb array				Fibrograph			Pressley strength	
		Upper quartile length	Mean length	Coefficient of variability	Fibers shorter than ½ inch	Upper half mean length	Mean length	Uniformity ratio	"0" gage	⅛-inch gage
1961 crop:	*Percent*	*Inches*	*Inches*	*Percent*	*Percent*	*Inches*	*Inches*	*Percent*	*Grams per tex*	*Grams per tex*
1. No drying	7.0	1.22	1.03	28	7.2	1.11	0.91	81	38.7	22.2
2. Light drying	5.1	1.21	.99	30	8.6	1.08	.88	81	38.8	21.2
3. Light drying plus vapor	6.3	1.23	1.04	27	6.7	1.12	.92	81	38.7	21.5
4. Light drying plus spray	7.3	1.22	1.04	27	6.6	1.11	.90	81	38.1	21.7
5. Heavy drying	4.9	1.19	.98	31	9.2	1.08	.86	80	38.2	21.1
6. Heavy drying plus vapor	5.6	1.21	1.01	29	7.8	1.09	.87	80	38.7	21.9
7. Heavy drying plus spray	6.2	1.21	1.02	28	7.3	1.10	.89	81	38.6	22.1
Analysis of variance [1]		NS	**	*	**	**	**	NS	NS	**
1962 crop:										
1. No drying	6.2	1.21	0.99	31	9.7	1.09	0.90	82	40.6	21.1
2. Heavy drying	2.7	1.17	.93	34	12.7	1.05	.83	79	39.2	20.0
3. Heavy drying plus vapor	3.6	1.19	.96	32	10.7	1.06	.87	82	39.0	20.1
4. Heavy drying plus spray	8.1	1.22	1.01	30	8.7	1.09	.91	83	39.7	20.8
Analysis of variance [1]		**	**	**	**	**	**	*	*	**

[1] NS means not significant; * means significant at the 95-percent level; and ** means significant at the 99-percent level.

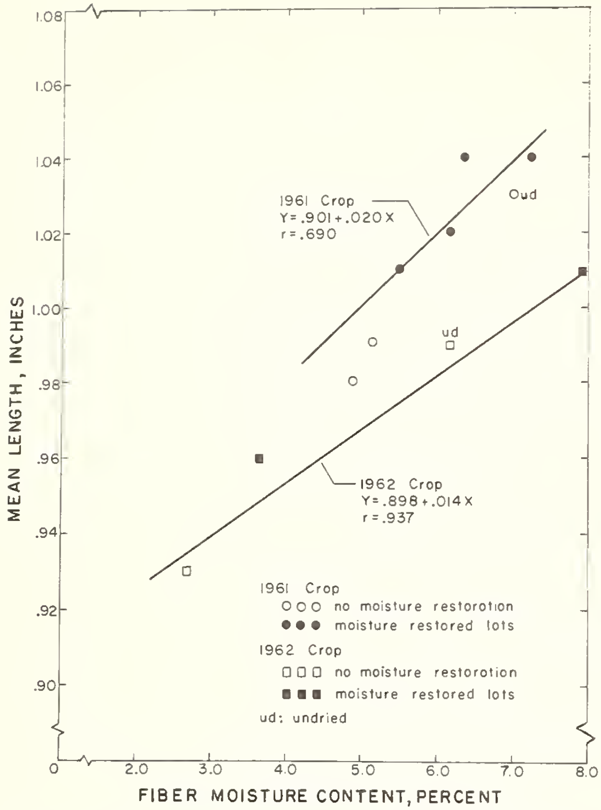

Figure 3.—Fiber mean length as affected by fiber moisture at ginning.

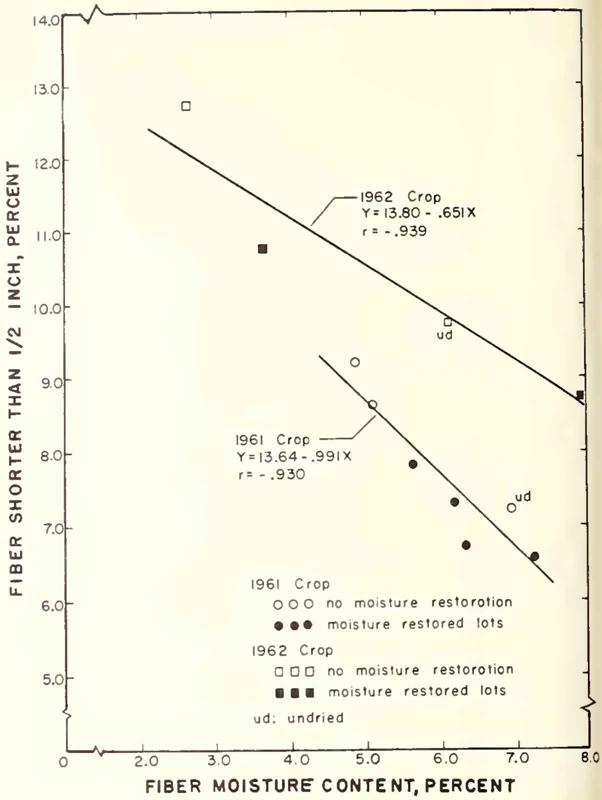

Figure 4.—Percentage of short fibers as affected by fiber moisture at ginning.

Fibrograph length data support the Suter-Webb array data (upper quartile and mean lengths) of fiber response to moisture in both ginned lint and card sliver samplings (table 3). Fibers in the ½-inch to 1-inch array length group had the same response pattern as those in the shorter-than-½-inch group, indicating that most of the fiber breakage occurred in the 1-inch-and-longer length group (table 4). These data show that potential losses in fiber length due to ginning at low moisture levels may be prevented by restoring enough moisture to cotton before it is ginned.

Fiber Bundle Strength

Fiber moisture content at ginning caused slight but highly significant changes in fiber bundle strength at ⅛-inch gauge testing. Bundle strength declined as moisture content declined, and it increased as moisture content increased (table 4). This trend indicates that losses in fiber strength due to drying are at least partially recoverable by restoring moisture to cotton before it is ginned. Of particular interest is the failure of certain lots to fully regain their original tensile strength even when moisture was restored to a level equal to or slightly more than the original moisture content. This reaction may be a problem of moisture distribution within and on the fiber, and these data should not be interpreted as meaning that fiber strength losses due to drying are not recoverable.

Neps, Yarn Evaluation, and Ends Down

Differences in nep count per 100 square inches of web were small and not attributed to moisture restoration (table 5). However, fibers of the 1962 crop cotton had a higher nep count that those of the 1961 crop.

Break factor analysis showed that yarn strength increased significantly with moisture restoration after drying (fig. 5). Test lots having the lowest break factors were those ginned at the lowest moisture level after drying but without moisture restoration. Highest strength was obtained from lots that had been ginned at the highest moisture content. These data clearly show (1) the dependence

TABLE 3.—*Fiber length distribution and fiber strength of card sliver for stated treatments—crops of 1961 and 1962*

Treatment	Fiber moisture content at feeder apron	Suter-Webb array				Fibrograph			Pressley strength	
		Upper quartile length	Mean length	Coefficient of variability	Fibers shorter than ½ inch	Upper half mean length	Mean length	Uniformity ratio	"0" gage	⅛-inch gage
1961 crop:	*Percent*	*Inches*	*Inches*	*Percent*	*Percent*	*Inches*	*Inches*	*Percent*	*Grams per tex*	*Grams per tex*
1. No drying	7. 0	1. 20	0. 98	31	10. 1	1. 10	0. 87	80	38. 6	22. 5
2. Light drying	5. 1	1. 18	. 94	33	11. 5	1. 06	. 82	77	38. 3	21. 7
3. Light drying plus vapor	6. 3	1. 21	. 98	32	10. 4	1. 10	. 87	79	38. 8	22. 1
4. Light drying plus spray	7. 3	1. 21	. 98	32	10. 2	1. 10	. 87	79	38. 4	22. 3
5. Heavy drying	4. 9	1. 17	. 92	35	13. 4	1. 05	. 82	78	37. 4	21. 7
6. Heavy drying plus vapor	5. 6	1. 20	. 95	33	11. 2	1. 08	. 85	78	37. 9	21. 8
7. Heavy drying plus spray	6. 2	1. 20	. 98	31	9. 4	1. 08	. 85	78	37. 9	22. 0
Analysis of variance [1]		*	*	*	**	*	*	**	*	NS
1962 crop:										
1. No drying	6. 2	1. 19	0. 94	33	11. 9	1. 07	0. 86	80	38. 9	21. 8
2. Heavy drying	2. 7	1. 14	. 89	37	15. 6	1. 03	. 81	79	38. 4	21. 3
3. Heavy drying plus vapor	3. 6	1. 16	. 91	35	13. 6	1. 05	. 84	79	38. 4	21. 0
4. Heavy drying plus spray	8. 1	1. 20	. 96	33	12. 0	1. 07	. 87	81	38. 8	21. 6
Analysis of variance [1]		**	**	**	**	**	**	NS	NS	NS

[1] NS means not significant; * means significant at the 95-percent level; and ** means significant at the 99-percent level.

TABLE 4.—*Fiber moisture, length distribution, and single strand yarn characteristics—crop of 1962*

Item	No drying	Drying	Drying plus vapor	Drying plus spray	Difference among treatments [1]
Moisture content: Fiber feeder sample percent	6.2	2.7	3.6	8.1	----------
Ginned lint fiber length distribution:					
Fibers shorter than ½ inch ... percent	9.7	12.7	10.7	8.7	**
Fibers ½ inch to 1 inch ... do	30.1	36.1	31.6	28.0	**
Fibers 1 inch and longer ... do	60.2	51.2	57.7	63.3	**
Card sliver fiber length distribution:					
Fibers shorter than ½ inch ... do	11.9	15.6	13.6	12.0	**
Fibers ½ inch to 1 inch ... do	34.9	38.1	37.5	32.6	**
Fibers 1 inch and longer ... do	53.2	46.3	48.9	55.4	*
Yarn single-strand evaluation and imperfections:					
Strength ... grams	190.9	174.2	178.5	191.3	**
Strength coefficient of variability ... percent	11.8	11.7	12.0	10.9	NS
Elongation ... do	6.6	6.5	6.4	6.5	**
Neps per 1,000 yards ... number	1191	1252	1202	1180	NS
Thick places per 1,000 yards ... do	1656	2147	1793	1561	**
Low places per 1,000 yards ... do	450	792	465	410	NS
Irregularity coefficient of variability ... percent	22.5	23.9	22.7	22.2	**

[1] NS means differences are not detectable by statistical test; * means differences are detectable at the 5-percent significance level; and ** means differences are detectable at the 1-percent significance level.

TABLE 5.—*Neps, yarn properties, and ends down for stated treatments—crops of 1961 and 1962*

Treatment	Feeder apron fiber moisture content	Neps per 100 square inches of web	Yarn property and ends down [1]			
			Yarn size	Break factor	Yarn appearance	Ends down per 1,000 spindle hours
1961 crop:	*Percent*	*Number*	*Number*	*Units*	*Index*	*Number*
1. No drying	7.0	7	40.2	2,004	93.3	53
2. Light drying	5.1	6	40.0	1,828	103.3	55
3. Light drying plus vapor	6.3	8	40.1	1,980	100.0	48
4. Light drying plus spray	7.3	7	39.9	1,964	103.3	45
5. Heavy drying	4.9	7	40.3	1,781	100.0	66
6. Heavy drying plus vapor	5.6	7	40.1	1,876	100.0	45
7. Heavy drying plus spray	6.2	7	39.9	1,865	96.7	52
Analysis of variance [2]	----------	NS	NS	**	NS	NS
1962 crop:						
1. No drying	6.2	17	38.2	1,869	105	65
2. Heavy drying	2.7	18	38.6	1,692	105	73
3. Heavy drying plus vapor	3.6	19	38.7	1,761	103	60
4. Heavy drying plus spray	8.1	19	38.4	1,890	101	66
Analysis of variance [2]	----------	NS	NS	**	*	NS

[1] 1961 crop: Twist multiplier, 3.62; yarn size desired, 40.0; and spindle speed, 12,000 r.p.m. 1962 crop: Twist multiplier, 4.09; yarn size desired, 39.0; and spindle speed, 10,000 r.p.m.

[2] NS means not significant; * means significant at the 95-percent level; and ** means significant at the 99-percent level.

of yarn strength upon fiber moisture at ginning, and (2) that degradation of the properties that contribute to yarn strength may be prevented by controlling fiber moisture at the gin stand.

Except in the no drying treatments of 1962, gin drying alone improved yarn appearance, but these improvements were diminished by restoring moisture before ginning.

Ends down per 1,000 spindle hours were highest for heavy drying without moisture restoration (table 5). There was a reduction in ends down when moisture was restored by vapor or spray methods at both levels of drying (fig. 6).

Single Strand Evaluation and Yarn Imperfections

Single strand studies on the 1962 crop cotton supported other yarn test data (table 4). Tests showed that heavily dried lots had the lowest yarn strength. Highly significant strength increases were obtained when moisture was restored.

Moisture restoration after drying decreased the nep count per 1,000 yards, significantly decreased thick places and low places per 1,000 yards, and lowered the irregularity coefficient of variability (table 4).

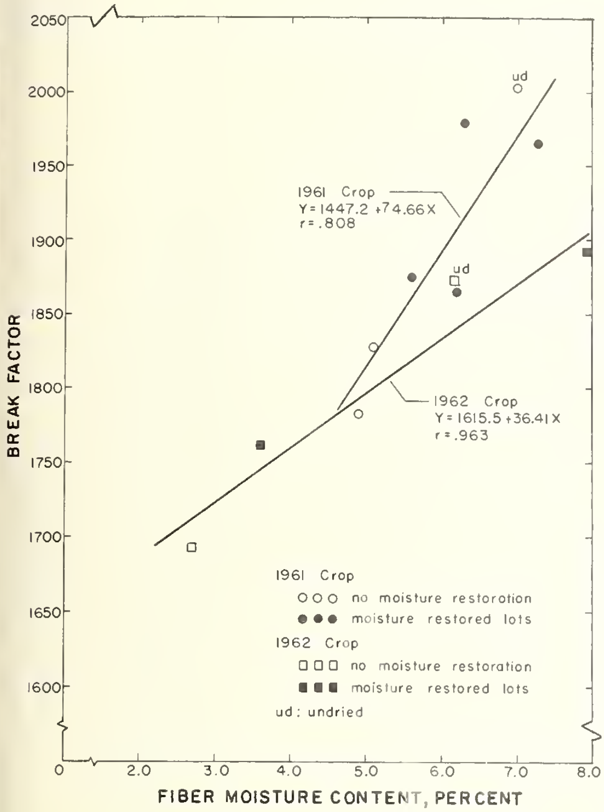

FIGURE 5.—Yarn break factor as affected by fiber moisture at ginning.

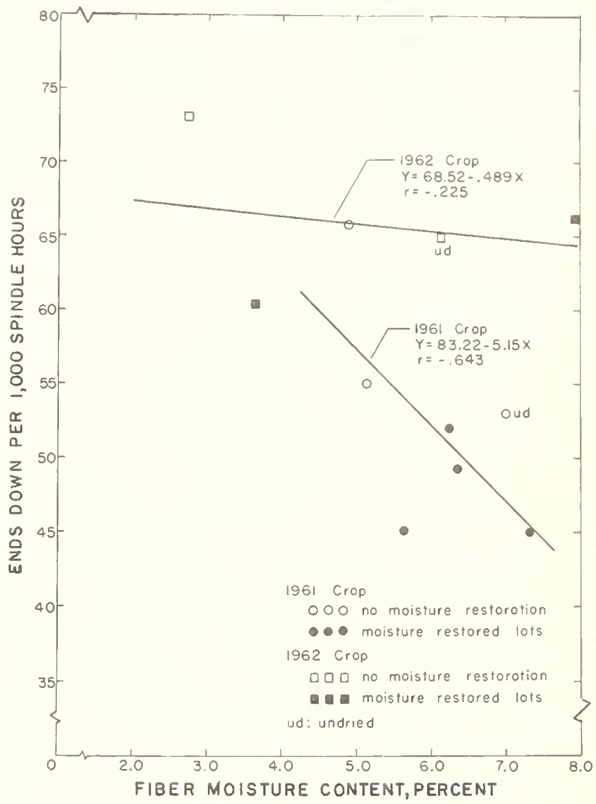

FIGURE 6.—Ends down as affected by fiber moisture at ginning.

CONCLUSIONS

The restoration of moisture to seed cotton after drying and overhead cleaning but prior to ginning and cleaning the lint demonstrated that cotton fibers do not readily absorb moisture and that a long exposure to a moisture-restoring medium is required if a substantial quantity of moisture is to be restored to dry cotton. If moisture distribution and exposure time are adequately controlled, either the vapor or the spray method satisfactorily prevents loss of fiber properties due to gin drying. Vapor systems are now available that expose cotton to moisture for a longer time than when this study was conducted.

As a rule, grade index slightly decreased when moisture was restored to cotton after drying but not enough to cause a grade change in the designation. There was a slight decrease in yarn appearance index as moisture was restored, but it caused no change in grade designation.

Fiber and spinning properties reacted in the following ways to the restoration of moisture after seed cotton drying and cleaning but before its ginning:

1. Upper quartile length, upper half mean length, and mean length increased.
2. The coefficient of length variation was lowered.
3. Fibers shorter than one-half inch and those one-half inch to 1 inch in length decreased in percentage.
4. Fibers 1 inch in length and longer increased in percentage.
5. Fiber strength and yarn break factor increased.
6. Ends down were reduced in number.
7. Yarn imperfections (single strand) decreased.

U.S. GOVERNMENT PRINTING OFFICE: 1965 O—773-840