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Moisture and Freezing Influences on Barkiness of Cotton Plant Branches

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MOISTURE AND FREEZING INFLUENCES ON BARKINESS OF COTTON PLANT BRANCHES

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SUMMARY

Barky lint is a problem peculiar to stripper-harvested cotton and is the source of bark strands in the plant branches removed during harvest. A 3-year study was conducted at the Texas A&M University Agricultural Research and Extension Center at Lubbock to determine if weathering factors might influence the amount of bark removed from plant branches during harvesting and ginning. Experiments measured stick moisture content, wetting and drying of sticks, and severity of the initial plant-killing temperature. Stick barkiness properties were measured by brittleness index, percentage of broken sticks, and quantity of loose bark slivers attached to broken sticks.

Stick moisture content was most highly correlated with stick barkiness measurements. Moisture content explained 83, 83, and 52 percent, respectively, of the variation in bark indicated by stick brittleness index, percentage of broken sticks, and quantity of loose bark slivers from broken sticks. Stick brittleness and percentage of broken sticks increased when stick moisture was below 16 percent. Wetting and drying, and severity of the initial plant-killing temperature, had minor effects.

INTRODUCTION

Successful mechanical stripper harvesting requires that the cotton plant be defoliated and dry to promote the separation of the boll from the branch during harvest. The stripper harvester removes bolls across a range of

plant conditions, but the quantity of foreign material in the bolls (primarily leaves and branches) varies considerably depending on the condition of the plant. The quantity of foreign material affects both the level of fine trash in the ginned lint and the lint grade.

One of the trash components in lint is called bark, produced by breakage and peeling of the outer cover of the branch during harvesting and gin processing. Excessive quantities of bark in ginned lint can result in quality grade reductions that lower its value. During 1966 to 1982, from 3 to 63 percent of the crop classified by the USDA Cotton Classing Office at Lubbock, Texas was reduced in grade because of bark (1). In a study by Morey et al. (1978) (2), most of the barklike strands removed from lint in the gin were identified as phloem fibers and a few strands as wood fragments.

Branches that break off from the plant during harvest are called sticks when they become part of the material stripped from the plant. The condition of the plant greatly influences the quantity of sticks that are harvested. Large, dry plants, when stripped, have been shown to produce cotton with large amounts of sticks (3,4).

There are at least two factors that determine bark content in ginned lint--the quantity of sticks and stick condition as it relates to the removal of bark from the stick. Weathering history affects the condition of plant branches at harvest, but the relationship of specific weathering factors to stick condition influencing the generation of bark is not well understood.

This study examines the effects of stick moisture content, wetting and drying cycles, and severity of the initial plant-killing temperature on plant branch breakage and generation of bark slivers.

METHODS

Moisture

The effects of stick moisture content and wetting-drying cycles on stick breakability and barkiness were studied in 1978 and 1979.

Whole green plants of the varieties Paymaster 909 and Dawson B-25 were cut off at ground level on October 19, 1978 and October 22, 1979, and the branches were removed from the main stem. Leaves and bolls were removed from the branches and the branches were cut to 15-cm sticks. The sticks were grouped in samples of 40, and initial moisture content was measured. The samples were then placed in trays to air-dry under ambient conditions for one week before wetting-drying treatments were imposed. Each sample was placed in a drying tray divided into 30 X 30 cm cells with hardware cloth bottoms and covered with 3 mil polyethylene to prevent stick wetting by rainfall or dew.

The following treatments were imposed on the sticks: (1) one wetting-drying cycle; (2) two wetting-drying cycles; (3) three wetting-drying cycles; and (4) no wetting (check). There was a 2-week period between wettings in treatments 2 and 3. The wetting part of each wetting-drying cycle consisted of submerging the samples in 20°C tap water for 20 minutes. The air-dry stick moisture content and moisture content following soaking, after surface water evaporated, were determined for each wetting. All samples remained covered in the drying trays except during the wetting treatments.

The stick characteristics after the final wetting of each treatment were measured 3 times at 2-week intervals. Four samples of each treatment were analyzed during measuring. Check samples were measured every time a stick analysis was made on any of the other treatments. Stick measurements included: moisture content, number of broken sticks, brittleness index, and

weight of bark slivers produced on the broken sticks. Number of broken sticks was measured by counting the sticks that broke while being deflected through a 45° angle. Brittleness index was determined by placing sticks inside a caulking gun and counting the number of "clicks" of compression up to the point the stick broke by bending. Differences among treatments within dates of sampling were statistically analyzed using Duncan's new multiple range test.

Temperature

The study in 1980 was designed to measure the effect of the severity of the first plant-killing temperature on stick barkiness. On October 16, green plants from the variety Paymaster 909 were cut off at ground level and brought into the laboratory. All bolls and leaves were removed from branches, and 15-cm branch sticks were cut. A total of 21 groups of 160 sticks were prepared. Each group was placed in a plastic bag for storage overnight in a cooler to prevent drying.

On October 17, 9 bags were exposed to -1.1°C and 9 bags to -6.7°C. Three bags were left at room temperature. Bags were grouped in thirds; exposure times to each temperature were 2, 4, and 8 hours. After exposures were completed, all sticks were removed from bags and placed in trays for air-drying. Stick properties were measured after drying on October 21, October 28, and December 2. For analysis each group of 160 sticks was divided into 4 replications (reps) of 40 sticks.

Measurements included stick moisture content at the beginning of the study and on each date of stick breakage. Brittleness index, number of broken sticks, and weight of bark slivers from the broken sticks were determined by the methods used in 1978 and 1979.

The experimental design was a split-split plot where main plots were temperature, subplots were stick moisture content, and sub-subplots were exposure

time to freezing temperature. Each treatment was replicated 4 times. Differences within levels of main plots, subplots, and sub-subplots were analyzed using Duncan's new multiple range test.

RESULTS

Moisture

The stick moisture contents before wetting were higher in 1978 than in 1979 (Table 1). In spite of the differences in moisture before wetting, the 20-minute soaking in water resulted in a rather constant increase in moisture ranging from 10 to 14 percentage points.

Moisture levels of sticks for each 1978 date of stick analysis showed that moisture was lost in the outdoor drying trays between October 25 and December 20, then increased until the last date of January 31 (Table 2). The increase in moisture for the last two dates was due to the sticks equilibrating to the more humid environment of damp, cloudy weather. Moisture levels of the sticks in 1979 decreased rapidly from October 22 to October 29. The fluctuations in stick moisture between October 29 and February 1 generally followed the cycles of dry and damp weather conditions. The lowest average moisture content recorded was 9.6 percent on December 3. Moisture content of sticks in both years closely followed moisture conditions of ambient air.

There were significant differences in stick brittleness index in the 1978 study on December 20 and January 10 (Table 3). The general trend was for sticks that had received the highest number of wetting-drying cycles to be the most brittle (indicated by lowest brittleness index). Stick brittleness (Table 3) was primarily influenced by the changes in stick moisture levels (Table 2).

The percentage of sticks that were broken when deflected through a 45° angle also was affected primarily by stick moisture content (Table 3). In

1978, percentage of broken sticks was between 35 and 45 percent when stick moisture contents were between 18 and 29 percent. Stick breakage doubled to 84 percent when stick moisture decreased to 13.6 percent on December 20. This agrees with the results from stripper-harvesting single plants where plant branch moistures below 16 percent caused a significant increase in numbers of sticks, mean stick length, and the percent of sticks that were whole branches (4). The number of wetting-drying cycles did not affect the percentage of broken sticks. The total weight of bark slivers was not affected significantly by the number of wetting-drying cycles, but it showed a high sensitivity to stick moisture content where bark sliver weight increased as stick moisture content increased.

The stick brittleness index in 1979 (Table 4) generally followed the fluctuation in stick moisture level (Table 2). The number of wetting-drying cycles significantly influenced stick brittleness on December 20 when treatment 3, representing the highest number of wetting-drying cycles, resulted in a high level of stick brittleness. Percentage of broken sticks also was affected primarily by moisture content. On December 20, the percentage of broken sticks in the check treatment was significantly lower than treatment 3, which was exposed to 3 wetting-drying cycles. On the other hand, total bark sliver weight was unaffected by the number of wetting-drying cycles.

Temperature

The cotton branch sticks were not hard-frozen by any of the exposure times to either -1.1°C or -6.7°C. Initial stick moisture content was 190 percent dry weight basis (dwb). Stick moisture content at each date of analysis was unaffected by length of exposure or temperature level (Table 2).

Temperature level affected none of the stick barkiness properties (Table 5). A decrease in stick moisture significantly increased brittleness (smaller brittleness index value) and percentage of broken sticks, but did

not affect the weight of bark slivers. Exposure times of 4 and 8 hours to low temperature caused a statistically significant decrease in stick brittleness and percentage of broken sticks compared to an exposure of 2 hours. This result may be due to greater cell damage caused by longer exposure to freezing temperature. Severely damaged cell walls could make a stick more flexible and, therefore, more tolerant of bending stress. The check was less brittle on the first measurement date (22 percent moisture content) than the other treatments. However, at the two later dates (10 percent moisture content) the check had brittleness index and percent broken stick values similar to that of the low-temperature treatments.

DISCUSSION

The relationship between stick moisture content and the measurements made as indicators of stick barkiness (brittleness index and percentage of broken sticks) were investigated using regression analysis (Table 6). A second-order curvilinear relationship existed between stick moisture content and both brittleness index and percentage of broken sticks in 1978 and 1979. Brittleness index and percentage of broken sticks were highly related in all 3 years.

Stick moisture content was consistent with brittleness index and percentage of broken sticks, during 1978, 1979, and 1980 (Figures 1 and 2). Brittleness index and percentage of broken sticks also displayed a consistent relationship (Figure 3). Since these data were collected over differing conditions of wetting and drying and exposure to low temperatures, these parameters appear to have little, if any, effect on the relationship between the variables in Figures 1, 2, and 3.

Among stick properties measured, total bark sliver weight removed from broken sticks should be the most direct indicator of stick barkiness. Stick moisture, brittleness index, and percentage of broken sticks were

related to bark slivers; however, these regression relationships had lower coefficient of determination (R^2) values and varied more among years than did the relationships among the other stick properties (Table 6). When the data from three years were combined, the relationships of weight of bark slivers with stick moisture content, percentage of broken sticks, and brittleness index had R^2 values of 0.52, 0.04, and 0.12, respectively. Of the three R^2 values, only the values for stick moisture content and weight of bark slivers were statistically significant. Obviously, stick moisture content had an effect on barkiness. However, other factors apparently influenced the quantity of bark peeled from the sticks. In examining the data, there was no apparent year effect which would suggest or explain low R^2 values.

CONCLUSIONS

The results presented in Tables 3, 4, and 5 lead to the conclusion that stick moisture content had more effect on stick brittleness than either length of exposure to low temperature or low temperature level, and that it is the dominant stick condition factor that determines stick brittleness, stick breakability and quantity of bark slivers. The number of cycles of wetting and drying or the severity of the first plant-killing temperature as imposed in these studies had little influence on stick barkiness properties.

In years when bark is a severe problem, barkiness generally increases as the harvest season progresses. In the 1981 season, the percent of bales classified as barky by the USDA Cotton Classing Office at Lubbock on a weekly basis began at 39 percent and increased to 90 percent for the final week (1). While there may have been some change in plant size in fields harvested early and late in the season, there certainly was

a decrease in plant moisture and longer exposure to weathering as the harvest season progressed. The decrease in plant moisture and the increase in barky bales support the results of this study, which showed that there was an increase in stick barkiness properties (brittleness index and percentage of broken sticks) as stick moisture decreased.

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TABLE 1. STICK MOISTURE CONTENTS BEFORE AND AFTER WETTING ON SIX DATES OF WETTING, 1978 AND 1979

Wetting Date	Stick Moisture, % dry weight	
	Before Wetting	After Wetting
1978		
OCT 25	34.9	46.7
NOV 8	31.9	41.2
NOV 29	22.1	32.0
1979		
OCT 29	17.8	31.3
NOV 12	18.3	29.5
DEC 3	8.3	19.4

TABLE 2. STICK MOISTURE CONTENTS, 1978, 1979, and 1980

Treatment	Date of Stick Analysis						
	Stick moisture, % dry weight basis						
	1978						
	Oct 19	Oct 25	Nov 8	Nov 29	Dec 20	Jan 10	Jan 31
1	195	----[1]	21.4	18.2	13.2	----	----
2	193	----	----	18.8	13.2	18.3	----
3	189	----	----	----	14.6	18.2	20.0
Check	193	28.6	23.9	17.9	13.4	18.3	20.1
Average	193	28.6	22.7	18.3	13.6	18.3	20.1
	1979						
	Oct 22	Oct 29	Nov 12	Dec 3	Dec 20	Jan 14	Feb 1
1	155	----	17.0	9.4	14.4	----	----
2	162	----	----	9.6	14.7	11.0	----
3	157	----	----	----	13.7	10.7	17.6
Check	156	16.2	17.9	9.7	15.0	11.2	19.0
Average	158	16.2	17.5	9.6	14.5	11.0	18.3
	1980						
	Oct 21		Oct 28		Dec 2		
-1.1 C	24.3[2]		9.7		9.7		
-6.7	20.3		10.2		10.2		
Check	22.7		10.7		10.3		

[1] A line indicates the treatment was not measured.

[2] Freezing temperature exposure time had no effect on moisture content so the average moisture for three exposure times within each temperature was computed.

TABLE 3. EFFECT OF FOUR TREATMENTS ON STICK PROPERTIES ON SIX DATES, 1978

Treatment	Dates					
	Oct 25	Nov 8	Nov 29	Dec 20	Jan 10	Jan 31
	Brittleness Index[1]					
1	----[2]	9.95[3]	10.0a	4.45a	----	----
2	----	----	10.0a	3.78 b	6.80 b	----
3	----	----	----	3.88 b	6.38ab	8.63a
Check	9.75	9.70a	10.0a	3.48 b	7.98a	9.18a
Average	9.75	9.83	10.0	3.90	7.05	8.91
	Broken Sticks, %					
1	----	41.3a	41.3a	88.3a	----	----
2	----	----	39.5a	77.0a	30.8a	----
3	----	----	----	83.8a	40.0a	36.3a
Check	41.3	41.3a	45.8	88.3a	38.3a	34.5a
Average	41.3	41.3a	42.2	84.4	36.4	35.4
	Total Bark Slivers, g dry weight					
1	----	0.35a	0.28a	0.24a	----	----
2	----	----	0.25a	0.17a	0.09a	----
3	----	----	----	0.16a	0.10a	0.25a
Check	0.51	0.48a	0.42a	0.18a	0.11a	0.25a
Average	0.51	0.42	0.32	0.19	0.10	0.25

[1] Sticks which did not break were assigned a brittleness index value of 10.0.

[2] A line indicates that the treatment was not measured on this date.

[3] Numbers in the same column for the same characteristic followed by a common letter are statistically the same at the 0.05 level according to Duncan's new multiple range test.

TABLE 4. EFFECT OF FOUR TREATMENTS ON STICK PROPERTIES ON SIX DATES, 1979

Treatment	Dates of stick analysis: Oct 29	Nov 12	Dec 3	Dec 20	Jan 14	Feb 1
	Brittleness Index[1]					
1	----[2]	9.40a[3]	3.53a	8.18a	----	----
2	----	----	3.38a	7.53a	6.10a	----
3	----	----	----	5.95 c	4.95a	9.63a
Check	7.68	9.25a	3.33a	8.85ab	6.38a	9.38a
Average	7.68	9.33	3.41	7.63	5.81	9.51
	% Broken Sticks					
1	----	40.60a	90.6 b	51.3ab	----	----
2	----	----	91.3 b	54.4ab	83.10a	----
3	----	----	----	64.4a	75.0 a	27.5a
Check	65.6	43.1 a	98.1a	40.5 b	74.4 a	31.9a
Average	65.6	41.9	93.3	52.9	77.8	29.7
	Total Bark Slivers, g dry weight					
1	----	0.29 b	0.44a	0.15a	----	----
2	----	----	0.27a	0.25a	0.28a	----
3	----	----	----	0.21a	0.25a	0.09a
Check	0.09	0.43a	0.31a	0.12a	0.23a	0.15a
Average	0.09	0.35	0.34	0.18	0.25	0.12

[1] Sticks which did not break were assigned a brittleness index value of 10.0.

[2] A line indicates that the treatment was not measured on this date.

[3] Numbers in the same column for the same characteristic followed by a common letter are statistically the same at the 0.05 level according to Duncan's new multiple range test.

TABLE 5. TREATMENT EFFECT ON STICK PROPERTIES, 1980.

Factor	Brittleness Index[1]	Broken Sticks, %	Slivers, g[2]
Temperature, °C			
-1.1	4.49 a[3]	86.6 a	0.18 a
-6.7	4.71 a	87.1 a	0.17 a
Moisture Content, % dwb			
22	8.63 a	61.0 b	0.19 a
10	3.16 b	99.6 a	0.18 a
10	2.01 c	100.0 a	0.16 a
Temperature Exposure, Hrs.			
2	4.25 b	91.5 a	0.17 a
4	4.72 a	84.6 b	0.19 a
8	4.83 a	84.4 b	0.18 a
Check Moisture Content, % dwb			
22	9.70	26.0	0.08
10	4.08	100.0	0.18
10	2.08	100.0	0.14

[1] Brittleness values are averages of 10 sticks.

[2] Bark sliver weights are those slivers removed from the broken sticks.

[3] Numbers in the same column for the same factor followed by a common letter are statistically the same at the 0.05 level according to Duncan's new multiple range test.

TABLE 6. SUMMARY OF REGRESSION RELATIONSHIPS BETWEEN STICK PROPERTIES, 1978, 1979, and 1980

Variables	Form of Regression Relationship	Coefficient of Determination (R^2)		
Stick moisture, % dwb (x)		1978	1979	1980
Y - Broken sticks, %	Second Order	0.89[1/]	0.86[1/]	[2/]
Y - Brittleness index	Second Order	0.84[1/]	0.94[1/]	[2/]
Y - Total bark slivers, g	Linear	0.68[1/]	0.20[1/]	[2/]
Brittleness index, (x)				
Y - Broken sticks, %	Second Order	0.99[1/]	0.95[1/]	0.94[1/]
Y- Total bark slivers, g	Second Order	0.76[1/]	0.34[1/]	0.60[1/]
Broken sticks, % (x)				
Y - Total bark slivers, g	Second Order	0.62	0.19	0.85[1/]

[1/] Indicates values that are statistically significant at the 5% level of probability.

[2/] Regression relationships were not computed because there were only two stick moisture levels in 1980.

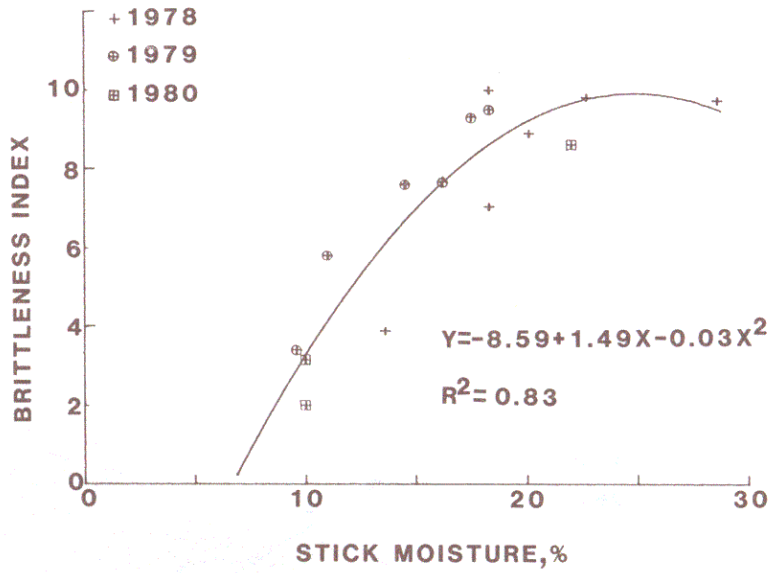

Figure 1. Relationship between stick moisture content and brittleness index, 1978-1980.

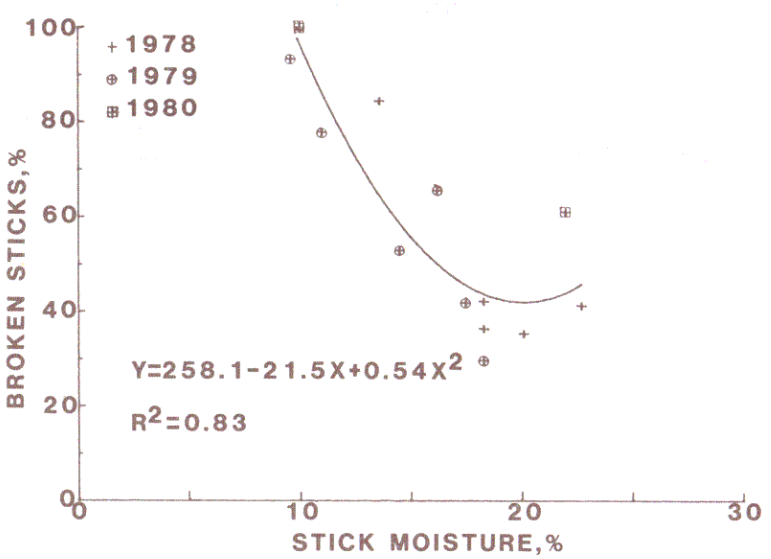

Figure 2. Relationship between stick moisture content and percentage of broken sticks, 1978-1980.

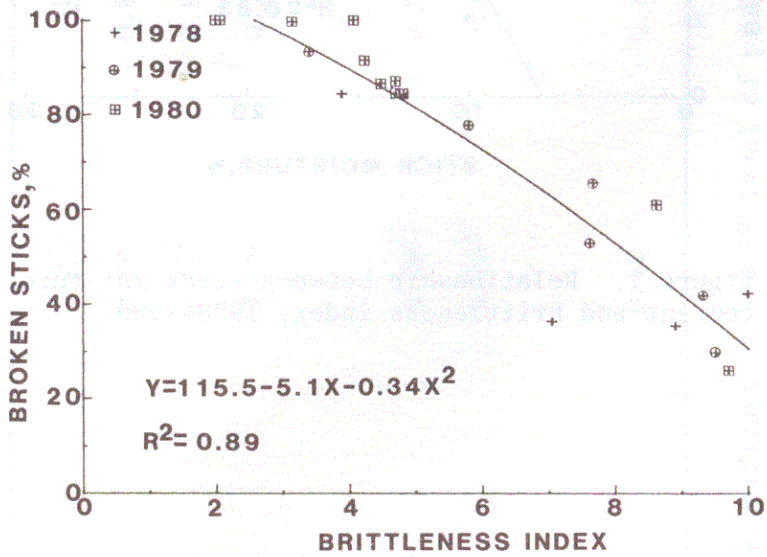

Figure 3. Relationship between brittleness index and percentage of broken sticks, 1978-1980.