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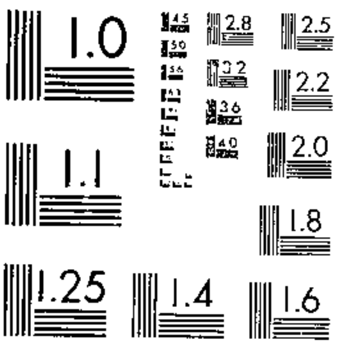

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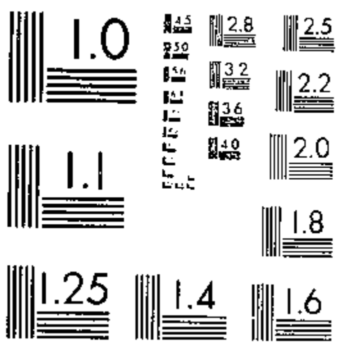

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DETERMINATION OF THE COMPRESSIVE CHARACTERISTICS OF LINT COTTON WITH A MODEL BALE PRESS

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DETERMINATION OF THE COMPRESSIVE CHARACTERISTICS OF LINT COTTON WITH A MODEL BALE PRESS

BY W. STANLEY ANTHONY and OLIVER L. MCCASKILL, *agricultural engineers, U.S. Cotton Ginning Research Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Stoneville, Miss.*

ABSTRACT

A split-plot experimental design was used to evaluate the force required to compress lint cotton in a model bale press, with a cross-sectional area of 144 square inches. Two significantly different varieties of cotton, four lint moistures, six densities, and three quantities of cotton were used as independent variables. Statistical analysis of data indicated that the effect of lint moisture content, density, quantity of cotton, and the interaction between moisture and quantity were significant at the 1-percent level of probability. The interaction between variety and moisture was significant at the 5-percent level of probability. Variety and the remaining interactions were not significant at the 5-percent level. A multiple linear regression analysis was performed on the combined 'Stoneville 213' and 'Pima S-2' data in order to develop a prediction equation for the model bale press. The accuracy of the prediction equation was increased greatly when logarithmic (base 10) transformations were made for compressive force and density. The regression analysis indicated that quantity of cotton was not a significant factor in the force required to compress lint cotton. The prediction equation is valid for the range of variables investigated in a press with a cross-sectional area of 144 square inches. Qualitative but not quantitative inferences relative to other sizes of presses can be drawn from the results of this experiment. The qualitative inferences include the form of the equation governing the compressive force variables involved, and the direction of influence of the variables.

INTRODUCTION

The system by which lint cotton is packaged in American gins has been criticized since its beginning in the 19th century. Widely diverse packaging methods and the practice of sampling a bale after it is packaged, combined with the rough handling that a bale receives during shipment, produce what is often called the "Ugly American Bale" (5).[1]

A number of bale types are produced in the United States, including the (1) gin flat, (2) modified flat, (3) gin standard, (4) gin universal density, and (5) compress universal density. Each of these types is compressed to a density, and restrained at a lesser density, the density in each case being dependent on the capabilities of the press, which vary from one system to another. Furthermore, gin flat and modified flat bales are usually re-pressed in a compress after initial packaging in a gin press. Overall, there is considerable variation in size, shape, and density among bales packaged in different systems.

Because the various packaging systems produce bales of different sizes, shapes, and densities, several handling techniques and modes of transportation are used to move bales of cotton to

[1] Italic numbers in parentheses refer to items in "Literature Cited," p. 10.

their ultimate destination. Handling damages frequently occur.

Efforts are being made to improve the appearance and quality of the American cotton bale (6). Automatic sampling at the gin prior to bale packaging, now being used on a limited scale (7), has the potential to greatly improve the external appearance of the bale. The trend toward producing only three types of bales—the modified flat, the gin universal, and the compress universal bale—will also help do away with many irregularities in American bales. The modified flat bale is intended for domestic use, whereas the last two types may be exported. The gin universal density bale is produced in a gin system capable of packaging a bale at a density of at least 28 pounds per cubic foot. The compress universal density bale is produced by re-pressing a modified flat bale in a compress.

Once established, the new packaging system will standardize sizes, shapes, and densities of bales, and that in turn will permit standardization of handling equipment and operations which will minimize handling damages. Despite these ongoing improvements, however, improving the American cotton bale requires more technology in many areas. One such need is the establishment of a prediction equation for the force required to compress lint cotton. The prediction equation would provide manufacturers with basic criteria to be used to satisfactorily design compressive systems.

Because several conflicts exist in published information pertaining to the force required to compress lint cotton (*1, 3, 4, 8, 9*), this investigation was undertaken to determine the force required to compress lint cotton and to resolve the conflicts in previously collected data. Some of the more easily recognized variables of which this force is a function are (1) the lint moisture content, (2) the density to which the lint cotton is compressed, (3) the quantity of cotton being compressed, (4) the physical properties of the lint cotton, (5) the distribution of the lint within the press box, (6) the time rate of compression, (7) the size of the press box, and (8) the friction of the cotton on the press box walls. This study seeks to establish the significance of the above variables in the compression of lint cotton.

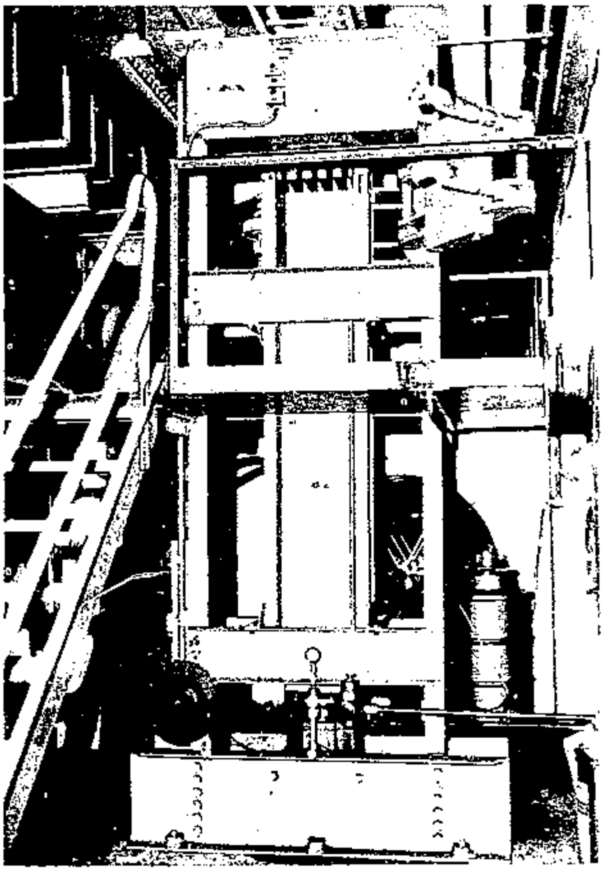
EXPERIMENTAL PROCEDURE

The initial step in developing an equation to represent compressive force is the establishment of the basic form of the relationship governing the force required to compress lint cotton. Preliminary investigation with the variables mentioned in the introduction indicated that four of those variables could adequately describe much of the variation in the data for a press of a given size. These variables were lint moisture content, density, quantity of cotton, and physical properties of the cotton.

Physical properties of cotton vary between and within varieties, depending on genetic makeup, growing conditions, and so forth. There has been much speculation on the compressive characteristics of different varieties of cotton, especially those of different staple length, strength, and micronaire. If every variety of cotton were considered, variation of each of the many physical properties would require a test too large to be manageable. For this reason, testing between two different varieties ('Stoneville 213' and 'Pima S-2') with widely differing physical properties was considered as a suitable alternative.

Research evaluating the force required to compress lint cotton was conducted with four factors: variety, moisture content, density, and quantity. Using 2 varieties, 4 moistures, 6 densities, 3 quantities of cotton, and 3 replications would require 432 test lots. However, 6 density levels can be obtained from 1 test lot of cotton by continuously monitoring the change in density, thereby reducing the required number of test lots to 72. Each test lot in a full-size system requires an average of 500 pounds of lint cotton. Using 72 of these 500-pound lots to conduct an experiment of this nature would not be physically or economically feasible.

It was felt that the model bale press at the U.S. Cotton Ginning Research Laboratory, Stoneville, Miss., could be used to develop detailed qualitative information relative to the force required to compress lint cotton, and would require substantially less cotton than a full-size press. The model press box has a cross-sectional area of 144 square inches, as compared to a full-size press box, which ranges from 1,025 to 1,475 square inches, and is 70 inches deep, or approximately the same depth as a full-size press box. Test lots of approximately 15 pounds are required for the model bale press, which means that the model bale press requires only 3 percent as much cotton as in the full-size system. A 55-gallon-per-minute hydraulic pump driven by a 50-horsepower electric motor develops compressive force in the



PN-[illegible]

FIGURE 1.—Up-packing model bale press shown with press box door open.

model press system. The hydraulic system develops pressure on an 8 -inch-diameter, up-packing ram. The model bale press is shown in figure 1. The hydraulic system is located outside the building.

Similitude analysis indicated that only the form of the relationship (linear, exponential, quadratic, logarithmic, etc.) and the relative importance of each variable could be easily determined from a model bale press, since quantitative results would require the evaluation of several distortion factors.

Furthermore, the accuracy of the experiment would be increased substantially by using the model system (2). First, since less cotton would be required to conduct an experiment with the model system, the homogeneity of the sample lots could be greatly increased, because uniform physical properties are more easily obtained with smaller quantities of cotton. Second, because the model bale press is located in a climatically controlled building, moisture distribution could be kept uniform in the experimental lots by conditioning at constant temperature and relative humidity. Third, the instrumentation used to monitor the compressive force in the model bale press is more accurate than the instrumentation in a full-size bale press.

A randomized complete-block split-plot experimental design was used to evaluate the force required to compress lint cotton. Two varieties of cotton, 'Stoneville 213' and 'Pima S-2', four levels of moisture content, six densities, three quantities of cotton, and three replications were used.

The seed cotton used in the experiment was mechanically harvested and held in storage approximately 6 months before being processed through three stages of seed-cotton-cleaning machinery in a full-size ginning system. The seed cotton was then conditioned and ginned at the ranges of temperature and relative humidity shown in table 1. The seed cotton was divided into lots of approximately 30, 45, and 60 pounds and placed on 4-foot-wide by 8-foot-long storage trays. The storage trays were spaced 12 inches apart vertically to allow the conditioning air to circulate freely through the seed cotton. After the lint portion of the seed cotton reached equilibrium with the conditioning air, test lots were processed through the model gin stand and one lint cleaner, except for the lots at the low moisture-content level (level 1). For the lots at the low moisture level, two multipath tower driers operated at 250 F (121.1° C) were also used in the ginning sequence immediately before the gin stand. Once through the gin stand, the lint was fed into the model bale press via a condenser and a lint slide, and the cotton tramped by hand into the press box.

The compressive force was measured by using

TABLE 1.—*Ranges of temperature and relative humidity used to condition and gin the seed cotton*

Lint moisture level	Lint moisture content (%)	Conditioning range: Relative humidity (%)	Conditioning range: Temperature (° F)	Ginning range: Relative humidity (%)	Ginning range: Temperature (° F)
1	2.37	18-22	88-90	20-22	90-91
2	4.76	30-34	72-76	31-32	74-75
3	6.81	54-58	88-92	56-58	89-93
4	8.55	81-84	84-90	76-81	90-95

Values are the average at each level for both varieties of cotton.

Cotton was conditioned for a period of at least 24 hours.

Seed cotton dryers were used to lower the moisture content.

a force transducer in conjunction with an eight-channel, direct-writing, strip chart recorder. The 100,000-pound-capacity transducer was placed on the fixed platen at the top of the press to monitor the force required to compress the test lots. The millivolt output of the tranducer was recorded on six channels with successively overlapping ranges.

As the ram was forced up by hydraulic fluid, the change in press box volume was monitored continuously by measuring the ram travel. Two microswitches broke an electrical circuit and actuated event markers on the recorder for every inch and every one-eighth inch of ram movement. The duplicate system of monitoring the change in press-box volume was necessary because of the exponential effect of the change in volume on density. Since the quantity of cotton was constant for each test lot, the density of the cotton could be determined in small increments by utilizing the change in platen separation as indicated by the microswitches. Densities were computed by dividing the quantity (weight) of cotton by the volume that the cotton could occupy as determined by the location of the bottom platen relative to the top platen.

RESULTS

Independent Variables

The various moisture contents and quantities of cotton used in this study are shown in tables 2 and 3, respectively. The levels are indicated for each variety of cotton. Average moisture contents of 2.37, 4.76, 6.81, and 8.55 percent were used. The average quantities of lint cotton used were 10.64, 15.96, and 21.56 pounds. Densities of 12, 17, 22, 27, 32, and 37 pounds per cubic foot were investigated.

The two varieties of cotton used have different genetic characteristics and were produced in different growth environments. As a result their lint physical properties were different. The 'Stoneville 213' was grown at Stoneville, Miss., under high-humidity, nonirrigated conditions, and the 'Pima S-2' was grown at Las Cruces, N. Mex., under low-humidity, irrigated conditions. With the exception of maturity index, the two varieties of cotton had significantly different (1-percent

(Continued on page 7.)

TABLE 2.—*Levels of moisture content used in evaluating the compressive characteristics of 'Stoneville 213' and 'Pima S-2' cotton*[1]

Bale designation[2]	Moisture content (%)	
	'Stoneville 213'	'Pima S-2'
11	2.22	2.10
12	2.47	2.25
13	2.50	2.39
Average	2.39	2.45
21	5.06	4.52
22	4.68	4.64
23	4.88	4.76
Average	4.87	4.64
31	6.90	6.76
32	6.79	6.79
33	6.95	6.68
Average	6.88	6.74
41	8.72	8.52
42	8.72	8.35
43	8.39	8.56
Average	8.61	8.48
Overall average	5.69	5.55

[1]Values are averages of 3 samples for each of 3 replications. The independent variable density was investigated at 12, 17, 22, 27, 32, and 37 lb/ft^3.

[2]The 1st digit of bale designation number indicates the moisture content level, the 2d, the quantity level.

TABLE 3.—*Quantity levels used in evaluating the compressive characteristics of 'Stoneville 213' and 'Pima S-2' cotton*[1]

Bale designation[2]	Quantity (lb)	
	'Stoneville 213'	'Pima S-2'
11	10.50	10.10
21	10.95	10.20
31	11.10	10.37
41	11.38	10.53
Average	10.97	10.30
12	16.02	14.70
22	16.30	15.10
32	16.87	15.67
42	16.85	15.95
Average	16.51	15.12
13	21.13	20.30
23	22.18	20.33
33	22.47	20.98
43	23.10	21.20
Average	22.33	20.80
Overall average	16.60	15.51

[1]Values are average of 3 samples for each of 3 replications. The independent variable density was investigated at 12, 17, 22, 27, 32, and 37 lb/ft^3.

[2]The 1st digit of the bale designation number indicates the moisture content level; the 2d, the quantity level.

TABLE 4.—*Physical properties used to designate varietal differences of 'Stoneville 213' and 'Pima S-2' cottons*[1]

Bale designation[2]	Fibrograph: 2.5% span length (in) S213	Fibrograph: 2.5% span length (in) Pima	Fibrograph: Uniformity ratio (%) S213	Fibrograph: Uniformity ratio (%) Pima	Strength 1/8-inch gage (g/tex) S213	Strength 1/8-inch gage (g/tex) Pima	Causticaire: Maturity index (%) S213	Causticaire: Maturity index (%) Pima	Causticaire: Fineness (ug/in) S213	Causticaire: Fineness (ug/in) Pima	Micronaire reading S213	Micronaire reading Pima
11	1.080	1.263	44.7	43.7	21.50	32.40	79.3	78.7	4.70	3.87	4.60	4.03
12	1.087	1.267	44.7	43.7	21.03	31.37	78.7	79.7	4.77	3.67	4.60	4.03
13	1.083	1.260	44.3	43.3	21.20	32.53	78.3	79.3	4.70	3.67	4.60	4.03
Average	1.083	1.263	44.6	43.6	21.24	32.10	78.8	79.2	4.72	3.74	4.60	4.03
21	1.103	1.280	46.0	44.0	21.43	32.47	78.7	78.7	4.70	3.73	4.60	3.97
22	1.110	1.277	45.0	44.7	21.33	32.90	79.3	79.7	4.67	3.73	4.60	4.07
23	1.107	1.287	45.7	44.7	21.13	32.20	78.7	78.0	4.73	3.77	4.60	3.97
Average	1.107	1.281	45.6	44.5	21.30	32.52	78.9	78.8	4.70	3.74	4.60	4.00
31	1.123	1.303	46.7	45.7	21.63	33.53	79.0	79.7	4.67	3.63	4.60	4.00
32	1.123	1.313	46.7	45.0	21.47	32.43	79.3	78.7	4.63	3.77	4.53	4.00
33	1.120	1.307	47.0	45.3	21.60	33.03	79.7	78.7	4.70	3.77	4.60	4.00
Average	1.122	1.308	46.8	45.3	21.57	33.00	79.3	79.0	4.67	3.72	4.58	4.00
41	1.140	1.310	47.3	45.7	22.03	32.63	79.7	79.3	4.63	3.63	4.60	4.00
42	1.137	1.320	48.0	46.7	22.10	33.30	79.0	79.3	4.67	3.77	4.57	4.10
43	1.137	1.317	47.3	46.0	21.73	33.60	80.0	78.7	4.60	3.67	4.63	4.00
Average	1.138	1.316	47.5	46.1	21.95	33.18	79.7	79.1	4.63	3.70	4.60	4.03
Overall average[3]	1.112a	1.292b	46.12a	44.88b	21.52a	32.70b	79.18a	79.02a	4.68a	3.72b	4.60a	4.02b

Bale designation	Staple length (1/32-in) S213	Staple length (1/32-in) Pima	Lint foreign matter content (%) S213	Lint foreign matter content (%) Pima	Grade index (%): Color S213	Grade index (%): Color Pima	Grade index (%): Leaf S213	Grade index (%): Leaf Pima	Grade index (%): Composite S213	Grade index (%): Composite Pima
11	34.3	44.0	3.20	1.33	94.0	102.7	94.0	102.9	94.0	102.7
12	34.2	44.0	2.88	1.55	94.0	102.4	94.0	102.6	94.0	102.4
13	34.0	44.0	2.77	1.77	94.0	102.4	94.0	102.7	94.0	102.4
Average	34.2	44.0	2.95	1.55	94.0	102.5	94.0	102.7	94.0	102.5
21	34.5	44.0	3.18	2.23	94.0	102.0	91.0	102.0	91.6	102.0
22	34.1	44.0	2.74	2.21	94.0	99.8	93.0	102.0	93.1	99.8
23	34.2	44.0	2.74	2.15	94.0	102.0	92.0	102.0	92.6	102.0
Average	34.3	44.0	2.89	2.20	94.0	101.3	92.0	102.0	92.4	101.3

See footnotes at end of table.

TABLE 4.—*Physical properties used to designate varietal differences of 'Stoneville 213' and 'Pima S-2' cottons*[1]—Continued

Bale designation[2]	Staple length (1/32-in)		Lint foreign matter content (%)		Grade index (%)					
					Color		Leaf		Composite	
	S213	Pima	S213	Pima	S213	Pima	S213	Pima	S213	Pima
31	34.7	44.0	3.46	2.26	94.0	102.0	89.0	100.9	88.0	101.4
32	34.8	44.0	3.93	2.38	94.0	100.9	87.0	99.2	90.3	98.7
33	34.9	44.0	3.43	2.40	94.0	101.4	85.0	100.3	88.3	100.3
Average	34.8	44.0	3.61	2.35	94.0	101.4	87.0	100.1	88.9	100.1
41	35.0	44.0	4.31	2.76	94.0	100.9	90.0	99.2	90.0	99.2
42	35.0	44.0	3.80	2.66	94.0	101.4	89.0	98.7	90.7	98.7
43	35.0	44.0	3.88	2.73	94.0	99.8	92.0	97.6	91.1	97.6
Average	35.0	44.0	4.00	2.72	94.0	100.7	90.3	98.5	90.6	98.5
Overall average[3]	34.6a	44.0b	3.36a	2.20b	94.0a	101.5b	90.8a	100.8b	91.5a	100.6b

[1]Values are averages of 3 samples for each of 3 replications. Values determined by Cotton Division, Agricultural Marketing Service, Clemson, S.C., with the exception of values for staple length and grade index, which were determined by the Cotton Division, Agricultural Marketing Service, Greenwood, Miss.

[2]The 1st number refers to the moisture content level, 2d to the quantity level.

[3]Overall averages not followed by the same letter are significantly different at the 1% level of probability as determined by *F*-test.

level) physical properties as determined by the F-test (table 4). The differences in the physical properties of 2.5-percent span length, uniformity ratio, strength (1/8-inch gage), causticaire (micrograms per inch), and micronaire for the two varieties of cotton are also shown in table 4. Table 4 indicates that staple length, foreign-matter content, and grade index were significantly different at the 1-percent level of probability as determined by the F-test.

Dependent Variable

The experimental data relating the force required to compress lint cotton in a model bale press to the independent variables are shown in table 5. The average compressive force varied from less than 600 pounds to nearly 102,000 pounds as lint moisture content, density, quantity, and variety changed.

Analysis of variance of the data as a split-plot statistical design is shown in table 6. The analysis of variance indicated that moisture content, density, quantity, and the interaction between moisture and quantity were significant at the 1-percent level of probability. The interaction between variety and moisture was significant at the 5-percent level of probability.

The two significant interaction terms (moisture times quantity and variety times moisture) indicate that the effect of moisture on quantity and variety is not the same at the different levels of each variable.

Regression Analysis

In order to establish the minimum number of variables necessary to describe compressive force, a regression analysis was conducted.

Using a linear regression analysis, the independent variables of moisture content, density, quantity of cotton, and variety were correlated individually to the force required to compress lint cotton. By this means the variations in data that could be attributed to each independent variable were determined. Use of a common loga-

TABLE 5.—*Compressive force associated with variation in variety, density, lint moisture, and quantity of cotton in the model bale press*[1]

Bale number[2]	Compressive force (lb) at density of 12 lb/ft³	17 lb/ft³	22 lb/ft³	27 lb/ft³	32 lb/ft³	37 lb/ft³	Lint moisture content ( )	Quantity cotton (lb)
S11	1,258	4,888	13,314	29,635	57,488	101,419	2.22	10.50
S12	1,379	4,998	12,968	27,655	51,911	88,654	2.47	16.02
S13	1,336	5,050	13,510	29,519	56,491	98,258	2.50	21.43
S21	1,474	5,335	13,821	29,451	55,163	94,203	5.06	10.95
S22	1,411	5,052	12,968	27,120	51,031	86,763	4.68	16.30
S23	1,124	4,236	11,314	24,685	47,152	81,985	4.88	22.18
S31	934	3,320	8,492	17,902	33,240	56,398	6.90	11.10
S32	868	3,187	8,348	17,936	33,830	58,179	6.79	16.87
S33	892	3,284	8,605	18,503	34,922	60,094	6.95	22.47
S41	681	2,553	6,787	14,756	28,408	48,715	8.72	11.38
S42	624	2,305	6,068	13,090	24,769	42,717	8.72	16.85
S43	522	1,980	5,293	11,555	22,083	38,412	8.39	23.10
P11	1,467	5,273	13,594	28,840	53,827	91,749	2.10	10.10
P12	1,508	5,451	14,113	30,045	56,243	96,095	2.25	14.70
P13	1,356	4,953	12,924	27,684	52,083	89,378	2.39	20.30
P21	1,317	4,815	12,360	26,112	48,659	82,750	4.52	10.20
P22	1,290	4,558	11,791	24,727	45,488	78,463	4.64	15.40
P23	1,173	4,320	11,340	24,112	46,114	79,409	4.76	20.33
P31	924	3,156	7,854	16,198	29,532	49,957	6.76	10.37
P32	862	3,012	7,602	15,850	29,192	49,170	6.79	15.67
P33	824	2,927	7,483	15,772	29,273	49,663	6.68	20.98
P41	793	2,718	6,767	13,966	25,172	42,573	8.52	10.53
P42	622	2,228	5,729	12,431	22,603	38,477	8.35	15.95
P43	571	2,087	5,358	11,334	21,099	35,884	8.56	21.20

[1]Values are the average of 3 replications.

[2]The S-prefix denotes 'Stoneville 213' cotton and the P-prefix denotes 'Pima S-2' cotton. The 1st digit of the bale designation number indicates the moisture content level; the 2d, the quantity level.

TABLE 6.—*Analysis of variance for the split-plot design used to evaluate the force required to compress lint cotton*[1]

Source of variation	Degrees of freedom	Sum of squares	Mean square	F
Replication	2	0.006	0.003	0.208ns
Variety	1	.027	.027	1.971ns
Error a	2	.027	.014	
Moisture	3	8.403	2.801	712.922**
Variety × moisture	3	.079	.026	6.665*
Error b	6	.024	.004	
Density[1]	5	162.108	32.422	13,083.811**
Variety × density	5	.029	.006	2.345ns
Moisture × density	15	.036	.002	.958ns
Variety × moisture × density	15	.041	.003	1.097ns
Error c	30	.074	.002	
Quantity	2	.105	.052	20.305**
Variety × quantity	2	.004	.002	.710ns
Moisture × quantity	6	.177	.029	11.402**
Density × quantity	10	.041	.004	1.576ns
Variety × moisture × quantity	6	.048	.008	3.104ns
Variety × density × quantity	10	.020	.002	.773ns
Moisture × density × quantity	30	.064	.002	.821ns
Variety × moisture × density × quantity	30	.066	.002	.853ns
Error d	248	.640	.003	
Corrected total	431	172.017	.399	

[1]Compressive force and density were coded to common (base 10) logarithms.
ns = not significant at the 5% level of probability.
** = significant at the 1% level of probability.
* = significant at the 5% level of probability.

rithmic transformation for compressive force increased the coefficient of determination (R^2) for each independent variable. The regression of moisture content on logarithmic force indicated that 5.1 percent ($100R^2$) of the sum of squares of logarithmic force could be attributed to moisture content. The linear regression of logarithmic density on logarithmic force indicated that 94.6 percent ($100R^2$) of the sum of squares of logarithmic force could be attributed to logarithmic density. A similar analysis with quantity of cotton as the independent variable accounted for only 0.25 percent of the sum of squares of logarithmic force. Virtually no correlation was obtained between compressive force and variety.

Addition of the significant interaction terms did not improve the efficiency of the regression equation.

Results of this analysis indicate that moisture content and logarithmic density should be included in a prediction equation for logarithmic force, whereas quantity of cotton and variety should be excluded for a given size of press.

Quantity of cotton was not important in accounting for the sum of squares of logarithmic force. The compressive force was not the same for the three quantity levels, but no pattern relating the compressive force to quantity of cotton emerged, and table 5 indicates that the variation in the compressive force at the three quantity levels is random. In some cases, more force is required to compress the smaller quantity; in others more force is required to compress the intermediate or larger quantity. Thus the difference in quantity is significant in the split-plot analysis but not in the regression analysis.

The multiple linear regression analysis of the data from the 'Stoneville 213' and 'Pima S-2' cotton yielded the following prediction equation:

$$\log F = 0.86065 - 0.05872M + 3.69843 \log P. \quad (1)$$

where F = compressive force (pounds),
M = lint moisture content, wet basis (percent),
P = density (pounds per cubic foot),
and log = common logarithm, base 10.

Equation 1 is valid only for a 144-square-inch

TABLE 7.—*Analysis of variance for the regression of moisture content and logarithmic density on logarithmic compressive force for a model bale press*

Source of variation	Degrees of freedom	Sum of squares	Mean squares	*F*
Attributable to regression	2	171.5	85.752	26.869
Deviation from regression	129	1.4	.003	----
Total	131	172.9	----	----

significant at the 1 level of probability.

TABLE 8.—*Regression analysis of the force required to compress lint cotton in a model bale press*

Variable	Standardized partial regression coefficient	Partial correlation coefficient	Standard error of regression coefficient	Computed *t*-value
Moisture	0.215	0.921**	0.001ns	-49.96**
Log density ...	.973	.996**	.016ns	226.45**

** significant at the 1% level of probability.
ns not significant at the 5% level of probability.

press. The coefficient of determination for equation 1 was 0.992, which indicated that 99.2 percent of the sum of squares of the dependent variable was attributable to the independent variables. Varietal effects had no influence on the force required to compress lint cotton.

The analysis of variance for the regression (table 7) indicated a highly significant (1-percent level) *F*-value attributable to the regression, which means that the association between the variables is not due to chance.

The relative importance and the direction of influence of moisture content and logarithmic density is shown in the more detailed regression analysis in table 8. Moisture content is negatively correlated while density is positively correlated.

Figure 2 shows in graph form the regression relationship between compressive force and density for 3, 5, and 7 percent moisture content. Figure 2 is valid only for a 144-square-inch press.

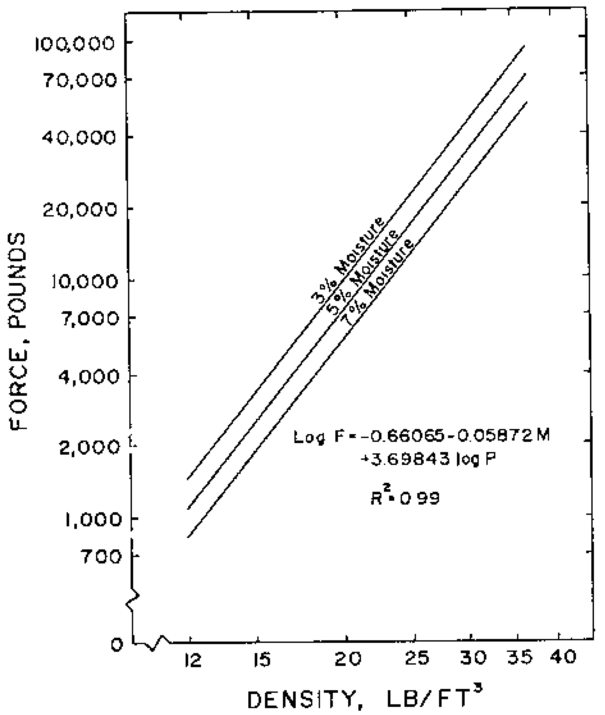


FIGURE 2.—Regression relationship between logarithmic force and logarithmic density at the 3, 5, and 7 percent moisture content levels for a 144-square-inch bale press.

CONCLUSIONS

The force required to compress lint cotton was found to be significantly influenced at the 1-percent level of probability by lint moisture content, density, quantity of cotton, and the interaction of moisture content and quantity. At the 5-percent level of probability, the interaction between variety and moisture was significant. The effect of variety and the remaining interactions on compressive force was not significant at the 5-percent level.

Multiple linear regression analysis of the effect of lint moisture content, density, quantity, and variety on compressive force indicated that quantity and variety were not significant in describing the data. Using lint moisture content and logarithmic (base 10) density as the independent variables, a coefficient of determination of 0.992 was obtained.

The split-plot analysis and the regression analysis differed as to the importance of the quantity variable. Since no consistent pattern relating quantity to compressive force developed even though a variation in compressive force attributable to quantity did exist, the regression analysis did not indicate a correlation, but rather included the variation in experimental error.

Addition of the significant interaction terms did not improve the efficiency of the regression equation.

Density was positively correlated to compressive force while moisture was negatively correlated. Density was over four times more important than moisture content, as judged by the standardized partial regression coefficients.

Common logarithmic (base 10) transformation for compressive force and density substantially increased the coefficient of determination.

Results of the experiment are valid only for a model bale press with a cross-sectional area of 144 square inches. Qualitative but not quantitative inferences can be drawn concerning other sizes of presses.

Data from this experiment cannot be used to directly improve the appearance of the American bale. However, the model study, having determined the relative importance of the variables involved in compressing lint cotton, establishes a basis for work to be conducted with full-size press systems.

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