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Review of Cotton Dust Control Technology Studies at North Carolina State University*

Cultural, Genetic, and Ginning Variations

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Studies of cotton dust control technology were initiated at the School of Textiles at North Carolina State University in 1973 using an especially designed model cardroom.[1] These investigations have focused on, among other things, the effectiveness of innovative cleaning and opening devices developed for use in cotton textile plants, as well as the use of steaming and cleaning systems at the gin so as to reduce dust emission during carding.[1,2] Also examined have been the influence of cotton cultural factors, such as geographic and temporal effects, harvesting technologies, and genetic variants.[3] Furthermore, the effects of washing cotton before processing and the addition of dust suppressants, additives, etc, on the dust emission have been studied.[2,4]

During the first three years of operation of the cardroom, hamsters and guinea pigs were exposed to the cotton dust. The animals were placed in the room while single bales of documented cotton were being processed. The maximum total exposure was about 21 hours over a three-day interval. After exposure, lung leukocyte recruitment was measured. In the early stages of the study, it was observed that exposure to steamed cotton did not significantly increase the lung cell count, while exposure to unsteamed cotton did.[1] Very few other significant effects were detected, however, probably because of the short exposure times and low dust concentrations involved. The animal tests were therefore discontinued at the end of 1976.

Concomitantly, a number of activities have been supported by this facility, such as the evaluation of cotton dust samplers,[2,5-8] characterization of the airborne dust,[2,5-16] and tracing the micronization of trash particles through processing.[17-18] The results of several of these studies have previously been reported. Much of the information collected, however, has not heretofore been disclosed. We review here the results of studies covering genetic, cultural, and ginning variations.

Materials and Methods

The design of the model cardroom and normal operating procedures for assessing the dust-generating potential of cotton have been described earlier.[1] Briefly, the equipment in the model cardroom consists of a single opener, feeder, and cotton card through which cotton is processed from bale to sliver. A laminar flow of recirculated, cleaned, and conditioned air moves through the room countercurrently to the flow of cotton. The dust released into the air during processing is measured with a large variety of gravimetric, short-term, and continuous air samplers.

To make proper statistical analyses of the data, normally at least two standard bales of cotton (approximately 480 lb/bale) are evaluated for each item being studied. Gen-

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erally one bale is processed on two consecutive days, half a bale each day. Some heavier bales are run in three parts on three consecutive working days. The replicate bale is then processed in a similar fashion at a later date. By following this procedure, it is possible to determine the variability within and between replicate bales. In practically all instances, the variability between bale parts is greater than the variability between bales;[1,4] consequently, differences between bales can be ignored.

In most cases, the statistical significance of any effect or treatment on the dust concentration measured is assessed by using the following model for analysis of variance:

$$y = b_o + T_i + B_j + (TB)_{ij} + \epsilon_{k(ij)}, \quad (1)$$

where b_o = mean dust concentration, T_i = treatment effect, B_j = bale effect, $(TB)_{ij}$ = interaction, and $\epsilon_{k(ij)}$ = the random error.

The two or three observations made on each bale (designated as a "part" or "run") were treated as replicate measurements. Since the bales of each cotton type are run in random order and carry no common identity, bale effects should not be significant, but bale-treatment interactions might be. A second statistical analysis is therefore made in which bales are nested within treatments. The nested analysis is of course the appropriate one for experimental designs in which bales carry no common identity. The crossed model given by Eq (1) is analyzed merely to verify that the first bales of any type processed indeed do not have a common identity. In analyses involving three or more treatments, Duncan multiple-range tests were utilized to determine which of the treatments are different from each other.[19]

In some comparisons involving only two treatments, a Student's *t*-test for comparing two sample means for unpaired observations is used. In this test, the SD for the difference between the two means (σ_d) is calculated from the relation

$$\sigma_d = \sqrt{\sigma^2(1/n_1 + 1/n_2)}, \quad (2)$$

where n_1 and n_2 are the number of observations in the first and second treatment means, respectively, and σ is the SD between replicate runs (the within-bale SD or experimental error). The value of σ for dust concentration measurements made with the vertical elutriator cotton dust sampler (VE) on 170 bales is 57 $\mu g/m^3$. For comparing mean dust concentrations based on four measurements each (n_1 and $n_2 = 4$), the value of σ from Eq 2 would be 40 $\mu g/m^3$. The 95 percent confidence interval for difference between such means would be 79 $\mu g/m^3$ (1.96 × 40 $\mu g/m^3$—the *t*-value of 1.96 applies because σ is known with over 170 df). For averages based on 6 and 8 replicates, the values of σ_d are 33 and 29 $\mu g/m^3$, respectively.

A great variety of bales of cotton with documented history were examined. Documentation of each bale was characterized by data such as its source, cultural, ginning, grading, and storage history. In the following review of results, only the most important contrasts are presented; a listing of cotton variety, grade, and state grown is included when judged appropriate. As reported earlier,[3,4] dust concentrations measured by the other samplers in the card room have a high correlation with the VE. Hence, results are presented only for the response of greatest interest, *ie*, the dust concentration measured with the VE sampler. The quality of the cotton is reported in terms of the classer's grade, a two-digit number. The first digit represents the classer's leaf index and the second is the color index. The lower the numbers, the better the quality of the cotton.

Results and Discussion

Cultural Variations

Cultural factors examined to date are listed in Table 1 in eight groups, including (1) the effects of early and late harvesting of cottons grown in one field, (2) the influence of desiccating (chemically killing) the plant before harvesting, (3) the effect of using a growth terminator before harvesting (four different growers), (4) the effect of harvesting with two different types of mechanical pickers (brush stripper and spindle), (5) the difference between cottons grown in two succeeding years on the same fields in 14 locations, (6) the differences between one variety of cotton (Deltapine 16) grown in five different states in one year, (7) the differences between six varieties of cotton grown in four states in one year, and (8) the differences between cottons containing high and low concentrations of Gram-negative rod bacteria.

The effect of the time of harvesting cotton grown in the same field is discussed first. The bales collected late in 1974 (all grown in Alabama) generated 50 $\mu g/m^3$ less dust (NS at the 95 percent level) than those collected about six weeks earlier, even though the grade of the latter cotton was poorer than that of the cotton collected earlier. In contrast, the bales collected late in 1973 (two varieties grown in Texas) generated more dust than did the bales collected four weeks earlier. Even so, the measured difference of 78 $\mu g/m^3$ for the Paymaster 909 variety is small and not likely to be of commercial consequence, especially since the effect of harvesting time was not consistent in the two crop years that this factor was examined. The data in Table 1 also indicate that killing the plant with a desiccant or terminating growth before harvesting does not significantly change the dust generated while processing the cottons.

Cotton harvested with a brush stripper harvester usually contains a lot more plant trash than cotton harvested with a spindle picker. The cotton harvested with the former device would therefore be expected to emit more dust than cotton picked with the latter device. This hypothesis was confirmed by the data (1,074 $\mu g/m^3$ compared with 684 $\mu g/m^3$).

The effects of growing locations and variety were examined in groups 5, 6, and 7 in Table 1. In the last of these, the cottons grown in 14 locations were collected from the same fields in two successive years. The average concentration of the dust emitted by the 1974 cottons differed from those of the 1975 crop by only 16 $\mu g/m^3$. Interactions existed, however, and in some locations the cottons grown in 1975 generated more dust during processing than those grown in 1974 in the same field; in other locations, the reverse was true. As reported previously,[3] Deltapine 16 cottons

Table 1—*Dust Concentrations Measured with Vertical Elutriator Cotton Dust Sampler (VE) While Processing Cotton in Model Cardroom—Cultural Variations*

Group No.	Cultural Variation	VE Dust Concentration: Mean, μg/m³	VE Dust Concentration: P Value[a]	Cotton Description: State Grown	Cotton Description: Variety	Cotton Description: Classer's Grade	Cotton Description: Year Grown
1	Harvested 11 Oct 1974	330		AL	Coker	31,41,41,32	1974
	Harvested 25 Nov 1974	280	NS[t]	AL	417	51,51,51,51	1974
2a	Harvested 1 Nov 1973	245		TX	Paymaster	31,32,41	1973
	Harvested 30 Nov 1973	321	**	TX	Dwarf	41,32,41	1973
2b	Harvested 1 Nov 1973	236		TX	Paymaster	41,41,41	1973
	Harvested 30 Nov 1973	314	**	TX	909	41,41,41	1973
2c	Desiccated	314	NS	TX	Paymaster	41,41,41	1973
	Not desiccated	269		TX	909	41,41,41	1973
3	Growth terminated, Grower 1	749		AZ	Deltapine 61	41	1976
	Not terminated, Grower 1	773	NS	AZ	Deltapine 61	41	1976
	Growth terminated, Grower 2	593	**	AZ	Deltapine 61	31	1976
	Not terminated, Grower 2	532	NS	AZ	Deltapine 61	31	1976
	Growth terminated, Grower 3	476	NS	AZ	Deltapine 61	41	1976
	Not terminated, Grower 3	527	NS	AZ	Deltapine 61	31	1976
	Growth terminated, Grower 4	371	NS	AZ	Stoneville 213	31	1976
	Not terminated, Grower 4	379	NS	AZ	Stoneville 213	31	1976
	Growth terminated, Av of 4	547		AZ	–	–	1976
	Not terminated, Av of 4	553	NS	AZ	–	–	1976
4	Brush stripper	1,074		CA	Acala SJ-2	22,33	1977
	Spindle picker	684	***	CA	Acala SJ-2	21,21	1977
5	Growing location	185		OK	Deltapine 16	32,33	1973
		265	***	SC	Deltapine 16	41,41	1973
		400	***	CA	Deltapine 16	41,41	1973
		436	NS	MS	Deltapine 16	41,42	1973
		558	***	AZ	Deltapine 16	41,41	1973
6	Variety and location	532		CA	Acala SJ-1	32,32	1973
		484	NS	TX	Stripper 31	42,42	1973
		365	**	TX	Paymaster 111	43,41	1973
		313	**	TX	Acala 1517	42,32	1973
		255	**	SC	Coker 201	41,41	1973
		206	**	MS	Stoneville 213	41,41	1973
7	Year grown (Av of 14 locations)[b]	397		[b]	[b]	–	1974
	Year grown (Av of 14 locations)[b]	381	NS	[b]	[b]	–	1975
8	High Gram-negative rod bacteria (1,400 cfu/mg)[c]	572		TX	?	?	1978
	Low Gram-negative rod bacteria (27 cfu/mg)[c]	672	**[t]	TX	?	?	1978

[a]Probability that observed difference would occur by chance. NS = P > 0.10; * = 0.10 > P > 0.05; ** = 0.05 > P > 0.01; *** = P < 0.01.
[b]Individual state and variety values for 1974, 1975: NM (Pima S-4) 658, 859; GA (McNair 511) 373, 524; TX (Paymaster 111) 329, 559; NC (Coker 310) 297, 521; OK (Lockett 4789A) 499, 274; AZ (Deltapine 16) 439, 361; NM (Acala 1517) 480, 247; AL (Coker 310) 495, 258; AR (Deltapine 16) 275, 372; MS (Stoneville 213) 360, 248; CA (Acala SJ-3) 318, 286; LA (Stoneville 213) 360, 248; TN (Coker 310) 269, 314; GA (Coker 201) 176, 342.
[c]Colony-forming units/mg of lint.
[t]Significance level judged by *t* test rather than analysis of variance.

grown in five states (group 5, Table 1) ranged from 185 to 558 μg/m³. Other varieties commonly grown in different parts of the cotton belt (group 6, Table 1) showed a similar range, from 206 to 532 μg/m³. This last group of bales was collected early in the study to determine whether any dominating factors influencing cotton dust emission could be easily recognized.

The effect of growing location, variety, and cotton grade on the dust produced during processing in the model cardroom has been discussed in detail previously,[3] as well as the difficulty of relating dust concentrations with cotton grade, growing location and variety. Other factors appeared to exert overriding influences. Caution must be exercised, therefore, in generalizing any conclusions.

It has been proposed that endotoxin from Gram-

negative rod bacteria may be the agent responsible for byssinosis.[20] Although there need not be any relationship between the concentration of respirable dust emitted from cotton and its content of Gram-negative rod bacteria, such a relationship might exist if weather conditions before harvesting lead to deterioration of cotton plant parts and to enhanced bacterial and fungal growth. In the single evaluation made (group 8, Table 1), a significantly higher concentration of dust was emitted from the cottons having the lower content of Gram-negative rod bacteria (672 vs 572 $\mu g/m^3$).

Genetic Variations

The genetic features of the cottons examined are listed in Table 2 in eight groups. These cotton variants include smooth leaf (without the fine covering hairs that might contribute to the respirable dust trapped in the lint); glandless (without the gossypol glands which produce terpenoid compounds, some of which have been suggested to be etiologic agents responsible for byssinosis);[21] nectarless (nectar is associated with insect resistance more than with dust); fuzzless or naked seed (expected to produce fewer linters and seed coat fragments and thus less dust); and frego bract (a smaller bract that wilts away from the boll as it dries). Red leaf and red stem varieties also were examined.

The results presented in Table 2 indicate that none of the genetic variations produced a systematic and reproducible effect on the dust-emitting characteristics of the cottons. For example, the smooth leaf cotton grown in 1975 generated less dust than the commercial hairy leaf cotton. The reverse was true, however, for the cottons grown the following year in the same field (groups 1 and 2). A reversal of effects is also evident when the glanded and glandless cottons are compared in groups 3 and 4. Similar reversals are observed when nectarless cottons are compared with standard cottons in group 2 (increase for nectarless) and in group 5 (decrease for nectarless). Frego bract cottons were no exception. Note the decrease in dust in group 5 and the increase in group 8 when compared with commercial cottons having standard bracts. Hand-picked frego bract cotton (group 7), the only bale of hand-picked cotton processed so far in the model cardroom, generated slightly less dust than machine-picked bales of the same cotton (158 and 199 $\mu g/m^3$, respectively).

It is evident that the genetic variants examined do not produce any systematic and reproducible changes in the amount of dust emitted during processing. It does not follow, however, that genetic variants have no beneficial effects. It is quite possible, for example, that breeding may eliminate the etiologic agent without significantly affecting the dust emission. Biologic evaluations would have to be carried out to determine whether these desired effects have indeed been achieved. Samples of the airborne dust have

Table 2—*Dust Concentrations Measured with Vertical Elutriator Cotton Dust Sampler (VE) While Processing Cotton in Model Cardroom—Genetic Variations*

		VE Dust Concentration		Cotton Description			
Group No.	Genetic Variation	Mean, $\mu g/m^3$	P Value[a]	State Grown	Variety	Classer's Grade	Year Grown
1	Hairy leaf (commercial)	342		SC	Coker 310	41,41	1975
	Smooth leaf	245	**	SC	Coker 420	41,41	1975
2	Hairy leaf (commercial)	218		SC	Coker 310	42,42	1976
	Smooth leaf	279	NS | **	SC	Coker 420	43,43,43,43	1976
	Nectarless	341	NS /	SC	Coker NF	33,33	1976
3	Glanded (commercial)	448		TX	Tamcot 788	42,42	1974
	Glandless	528	**[t]	TX	Gregg 35W	42,42	1974
4	Glanded (commercial)	136		NC	McNair 612	51,51	1975
	Glandless	107[b]	NS	NC	McNair 4-1206	51,51	1975
5	Glandless (commercial)	448		TX	Lambright GL-5	31,32	1977
	Glandless-nectarless	346	NS	TX	Lambright GL-N	31,30	1977
	Frego bract-glandless	383	NS	TX	Lambright	51,42,51	1977
6	Fuzzless	377		AK	–	61	1975
7	Red Stem	298		GA	–	42,42	1973
	Red Leaf	181	***[t]	GA	–	32,32	1973
	Frego bract, hand-picked	158	NS[t]	GA	–	21	1973
	Frego bract, machine-picked	199	NS[t]	GA	–	32,42	1973
8	Tamcot SP-37	186		TX	–	41,41	1977
	Frego bract	260	**	TX	–	41,31	1977

[a]Probability that observed difference would occur by chance. NS: $P>0.10$; *: $0.10>P>0.05$; **: $0.05>P>0.01$, ***: $P<0.01$.
[b]Single value. Andersen sampler concentrations were 0.15 $\mu g/m^3$ for glanded and 0.17 $\mu g/m^3$ for glandless.
[t]Significance level judged by *t* test rather than AOV.

been collected systematically for this purpose, and some of the results have been reported.[22-23]

Ginning Variations

The first ginning modification examined listed in Table 3 is that of steaming. Merchant et al[24] and Imbus and Suh[25] reported that steaming the cotton in the bale before carding reduced both the concentration of respirable dust generated during processing as well as the biologic activity of the dust. Because the lint is more open and accessible during ginning, it was believed that steaming at the gin might be more effective than steaming in the bale. All of these studies were made on cottons grown in Oklahoma.

As indicated in Table 3, four groups of experiments were made. Except for one experiment, all cottons not steamed were exposed to equivalent air pressure. In all four cases, steaming reduced the concentration of cotton dust emitted during processing. In one of the studies (1b), the cottons were stored in a warehouse for zero to eight months after ginning.[2] The concentration of dust emitted by the steamed and unsteamed cottons were found to increase after three months of storage. Cottons processed after storing for up to one month after treating generated an average dust concentration of 175 $\mu g/m.^3$ This level increased to 274 $\mu g/m^3$ for cottons stored 3, 5, and 8 months. The effect of steaming duration was examined in group 1d. No significant differences in dust concentrations were found for exposure times varying from 55 to 186 seconds.

Two cleaning devices were also examined in conjunction with the study reported in group 1c of Table 3. One device was a standard gin lint cleaner. The second is used as a cleaner in the bale opening process and is now called the Cottonmaster. As indicated in Table 3, increasing the number of lint cleaners at the gin from one to two or processing the cotton through the Cottonmaster both reduced the concentration of respirable dust emitted from the cotton during carding. In all cases, however, the reduction was small, since the cotton used in this experiment emitted an unusually low quantity of dust (the maximum observed in any run was 256 $\mu g/m^3$). In this experiment samples of cotton were also passed through the gin without

Table 3—*Dust Concentrations Measured with Vertical Elutriator Cotton Dust Sampler (VE) While Processing Cotton in Model Cardroom—Ginning Variations*

		VE Dust Concentration		Cotton Description			
Group No.	Ginning Variation	Mean, $\mu g/m^3$	P Value[a]	State Grown	Variety	Classer's Grade	Year Grown
1a	Steamed	335		OK	?	52	1973
	Not steamed	533	***[c]	OK	?	52	1973
1b	Steamed	207		OK	Westburn 70	43x5	1974
	Not steamed	262	*	OK	Westburn 70	43x5	1974
	Stored 0,1 month	175		OK	Westburn 70	43x4	1974
	Stored 3,5,8 months	274	**	OK	Westburn 70	43x6	1974
1c	Steamed	160		OK	Westburn 70	32,33,31,31[b]	1975
	Not steamed	191	**	OK	Westburn 70	33,32,32,31	1975
	One lint cleaner	190		OK	Westburn 70	33,32,32,31	1975
	Two lint cleaners	132	*	OK	Westburn 70	32,31,33,31	1975
	Cleaned with Cottonmaster	161		OK	Westburn 70	32,31,31,31	1975
	Not cleaned	180	NS	OK	Westburn 70	33,32,32,33	1975
1d	Steamed (average)	395		OK	Lockett 4789A	35,35,36,35	1973
	Not steamed (average)	550	***	OK	Lockett 4789A	35,35,35,35	1973
	Treated 55 sec (steam or air)	407		OK	Lockett 4789A	35,35	1973
	Treated 82 sec (steam or air)	517	NS	OK	Lockett 4789A	35,35	1973
	Treated 124 sec (steam or air)	506	NS	OK	Lockett 4789A	35,36	1973
	Treated 186 sec (steam or air)	461	NS	OK	Lockett 4789A	35,35	1973
2	Moisture added at battery condensor (7.2% moisture)	227		TX	?	52	1974
	No moisture added (2.7% moisture)	232	NS[c]	TX	?	42	1974
3a	Experimental seed cotton feeder-cleaner	241		?	?	31,31	1973
	Standard processing	245	NS[c]	?	?	31	1973
3b	Experimental seed cotton feeder-cleaner	349		TX	Paymaster 909	31,32,32	1977
	Standard processing	268	**	TX	Paymaster 909	32,32,32	1977

[a]Probability that observed difference would occur by chance. NS: $P>0.10$; *: $0.10>P>0.05$; **: $0.05>P>0.01$; ***: $P<0.01$.
[b]Grades for group 1c measured by instrument on lint from bale.
[c]Significance level judged by t test rather than by AOV.

being exposed to compressed air or steam. No significant differences were found in the concentration of dust emitted from the bales exposed to pressurized air and the unexposed bales. (An exception was noted for measurements made on the high volume samplers. The dust concentrations measured on these samplers were 417 and 514 $\mu g/m^3$ for the pressurized and unexposed bales, respectively).

In drier regions of the cotton belt, moisture in the form of steam is sometimes added to the seed cotton at the battery condensor in the gin to improve its baling characteristics. Since steaming is known to decrease the dust emission, the question arises whether this steaming at the battery condensor also decreases dust emission. To answer this question, two bales of cotton were collected without adding moisture to the cotton at the battery condensor. The results presented in Table 3 (group 2) indicate that the dust emission from the cotton with moisture added (7.2 percent moisture, 227 $\mu g/m^3$) is not significantly different from that emitted from the cotton without moisture added (2.7 percent moisture, 232 $\mu g/m^3$).

Two sets of experiments were made to test the influence of two experimental feeder-cleaners on dust emission during carding (groups 3a and 3b). These devices are used to clean the seed cotton before it enters the gin and can remove from 50 to 60 percent of the large trash, such as sticks and burrs, in the seed cotton. As shown in Table 3, however, removal of this trash does not reduce the dust emission in the model card room. The test made in 1977 (3b) actually shows an increase in card room respirable dust when the feeder-cleaner is used.

One piece of ginning equipment very effective in reducing the emission of respirable dust during carding is the lint cleaner.[1,26-28] The results of four groups of experiments in which the number of lint cleaners incorporated at the gin ranged from zero to three are summarized in Table 4. In every case, the airborne dust concentration was reduced in the cardroom when an additional lint cleaner was added. As might be expected, the largest reduction in dust level is obtained when the first lint cleaner is introduced. Although the decrements become smaller with each succeeding lint cleaner, the decreases obtained are quite desirable.

Table 4—*Dust Concentrations Measured with Vertical Elutriator Cotton Dust Sampler (VE) While Processing Cotton in Model Cardroom—Varying Number of Lint Cleaners Employed in Ginning*

No. of Lint Cleaners	Dust Concentration, $\mu g/m^3$				Average, $\mu g/m^3$	% Change
0	930	770	870	490	749	0.0
1	720	670	610	350	585	−21.9
2	440	540	380	330	424	−43.4
3	340	460	340	290	360	−51.9
Cotton Description						
State Grown	TX		TX		TX	CA
Variety	Coker 312		Stripper		Paymaster 111	Acala SJ-1
Year Grown	1973		1973		1973	1973

In the past it was common practice to use only one lint cleaner because repeated cleanings result in some fiber damage and fiber loss.[26] An economic optimum apparently was achieved (*ie,* improved cotton grade at the cost of slightly reduced fiber length and weight) with a single lint cleaner. With respirable cotton dust emission becoming a more critical factor, however, the use of additional lint cleaners is probably justified, especially for high strength fibers.

The Cardroom as a Source of Materials for Other Studies

One of the major difficulties impeding progress in cotton dust research has been the lack of documented cotton dust samples typical of the respirable dust actually present in cotton mills. Investigators in the past have been forced to work with samples of ground-up trash and settled dusts from cottons of unknown variety and origin or collected from different textile mills.

One utility of the model cardroom is that documented samples of dust and trash that have been airborne can now be collected for chemical analysis,[2,10-16] physical characterization,[5,7-11] and bioassay.[22-23] Many of these samples have been supplied to other investigators for evaluation. The microbial and fungal content of the cardroom atmosphere can also be monitored while cotton is being processed.[23,29-32] The types of samples collected and used are described.

Trash and Dust Samples from the Lint Capture System

Incorporated in the model card room is a Pneumafil lint capture system that vents air from several locations above the card, filters the captured air through a polyester filter held on a V-cell frame, and returns the air to the cardroom. Most of the lint and large particulate matter builds up on the filter, while much of the fine dust passes through. The material collected in the system is removed after each bale of cotton is carded and separated into two types of samples.

The first of these consists of relatively large, mostly lint-free, particulate matter that drops to the floor before it reaches the V-cell filter. Usually about 100 g of this material is collected from each bale. A number of these samples have been analyzed for proximate chemical composition.[2,12-14,33] Effects associated with growing location, cotton variety, lint cleaning at the gin, and steaming were considered in these analyses.[33] These samples have also been supplied for *in vitro* bioassays.[22-23]

The second sample obtained from the Pneumafil system comes from the material, mostly lint, collected directly on the filter. Fine dust is separated from the lint-cake removed from the filter using a Ro-Tap/Sonic Sifting procedure described by Brown and

Berni.[34] Dust fractions with theoretical diameters of 20 to 38 μm and <20 μm are collected. The < 20 μm fraction is mostly lint-free and is believed to be closely representative of the airborne, respirable cotton dust. A number of these samples have been analyzed for their chemical content,[2,14,16,33] and some of these have been supplied for bioassay to Dr. M.C. Battigelli and for microorganism studies to Dr. J.J. Fischer (University of North Carolina School of Medicine).

Vertical Elutriator Dust Samples

Many specialized studies have been made on dust collected with the VE. It has frequently been necessary to use different types of filters for these studies. For example, particle size distributions have been measured on dusts collected on polyvinyl chloride membrane filters[9] and on Nuclepore filters.[5] To measure the inorganic content of the dusts, samples must be collected on glass fiber filters. The average ash content of the samples examined was 20 percent, a value comparable to the ash contents found in cotton leaf and bract samples.[2,33] Dusts collected on cellulose ester filters have been analyzed for inorganic elements using x-ray fluorescence.[15] Major elements detected by this technique were Ca, Si, K, Fe, Al, S, Cl, P, Cu, Mn, Sn and Ba.

Electrostatic Precipitator Dusts

Samples of fine dusts recovered from the electrostatic precipitator that filters the air before returning it to the cardroom have been collected periodically after a number of bales have been processed. Chemical and petrographic analyses indicate that these dusts contain a high mineral content.[2,11,12,33]

Summary

The effects of several cultural, genetic and ginning variations on the amount of dust emitted while processing cotton in the model cardroom have been examined. Many growing and harvesting variations produced inconsistent results from year to year and growing location to growing location. The observed effects, although statistically significant in many cases, were relatively small except for differences introduced by using two different types of cotton harvesters. Cotton harvested with brush strippers was found to generate 57 percent more dust while processing than cotton harvested with spindle pickers.

None of the genetic variations examined produced changes in dust concentrations large enough to warrant a selection on this basis alone. Of course the main objective of many of the genetic changes, such as removing gossypol glands or introducing frego bracts, is not to reduce the quantity of respirable dust released during processing, but to reduce the biologic effects of the dust. Evaluation of the success in meeting this objective awaits results of appropriate biologic testing or identification of the etiologic agent or agents responsible for byssinosis.

The most successful methods for reducing the amount of respirable dust generated during cotton processing are associated with the ginning studies. In four studies, steaming the cotton in the gin was found to reduce consistently the cotton dust released into the cardroom during processing. The reductions varied from 16 to 36 percent. Using lint cleaners in the ginning line also consistently reduced the dust content of the cotton. In four separate evaluations, the use of one lint cleaner reduced the dust emitted from the cotton during processing by an average of 22 percent. With three lint cleaners, the total reduction averaged 52 percent.

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Sampling of Cotton Dust for Epidemiologic Investigations*

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Epidemiologic investigations are conducted to derive a dose-response relationship that specifies the amount of the cause that leads to a stated incidence of the effect. To determine the dose, dust sampling is carried out to measure one or more of the dust's properties that are expected to be related to the disease. Cotton dust is the most challenging type of dust because the causative agent is unknown, the particle size causing the disease is not well defined, and cotton dust does not lend itself to be classified into discrete size fractions by conventional types of particle size classifiers. Furthermore, the properties of cotton dust, and consequently its toxic potential, are varied among the various grades of cotton and also vary from one process to another.

We present our efforts in determining the dose and illustrate some of the related difficulties encountered during the evaluation of workers' exposure to cotton dust in two different types of industries—textile and cottonseed mills.

Textile Mills

Five textile mills were included in this study to detect and quantify adverse responses to low concentrations of cotton dust.[1] Mill I had processed cotton for four years and represented the combination of low current exposure and absent postexposure. Mill II had processed cotton for many years but had only lately achieved satisfactory dust control. Mills III, IV, and V are geographically close installations in which cotton dust exposure had been low for at least ten years. The

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