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EFFECTS OF INJURIES SIMULATING HAIL DAMAGE TO COTTON

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SUMMARY

Experiments on simulated hail damage to cotton were conducted in 1954 on dryland at the Main Station Farm at College Station and Substation No. 8 at Lubbock, and under irrigation at Lubbock and Ralls.

Similar tests were conducted in 1953. Results for the 2 years are similar and are summarized as follows:

Stands varying from 7,500 to 53,000 plants per acre had little influence on the yield of dryland or irrigated cotton at Lubbock or College Station.

Reductions of yield from thinning cotton have occurred only when thinning was accomplished 2 to 4 weeks after emergence.

Removal of leaves from cotton had its greatest effect at the time of flowering. Removing up to 50 percent of the leaf area decreased yield only slightly and removing 75 percent of the leaves in the early part of the growing season caused no loss. Total defoliation caused an appreciable loss at any time of the season.

Plants recovered from injuries much faster if a small amount of leaf tissue remained on the plant.

Losses resulting from plant cutoffs were relatively small in irrigated cotton at Lubbock when the injury was inflicted before July 1.

The removal of the terminal bud of cotton did not decrease yields although topping at square initiation may be harmful.

Cotton plants recovered from injuries as severe as complete stripping and low cutoffs, and showed the ability to regenerate damaged tissues.

Environmental factors dominated the recovery of cotton on dryland.

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Introduction

Experiments on simulated hail damage to cotton were conducted in 1954 at three locations. These included dryland tests on the Main Station Farm at College Station and Substation No. 8 at Lubbock, and irrigated experiments at Lubbock and Ralls.

These experiments were conducted to determine the effect of various injuries simulating hail damage on the yield and maturity of cotton. Samples for fiber analysis have been made and the results will be published in another report.

To simulate hail damage and provide information on specific and well-defined injuries, the four main types of hail damage (stand reduction, different degrees of leaf destruction, various stalk cutoffs and complete stripping of plants) were used separately and in several combinations on plots of cotton in field tests. All injuries were inflicted accurately by hand, and standardized field plot technique was used throughout.

Spacing of Cotton

Cotton is subject to thinning by hail from the day it is up to stand until several weeks afterwards. To simulate these conditions, plots of cotton at all locations were thinned to a spacing between plants of 3, 6, 10, 15 and 20 inches on the day of maximum emergence. Similar thinnings were continued on other sets of plots each week for 6 weeks.

There was no difference in yield due to spacing or date of thinning at College Station (Table 1). These results are similar to those of the 1953 tests at College Station. They indicate that stands do not limit yields on the poorer soils of Central Texas, and that thinning for several weeks after stand date does not cause any appreciable decrease in yield.

Table 1. Pounds of lint per acre produced by cotton thinned to various spacings at stand date and later intervals, College Station, 1954[1/]

Spacing, inches	Date cotton was thinned			
	May 3	May 10	May 24	June 7
3	214	254	231	213
6	216	226	251	246
10	226	246	243	215
15	220	233	233	201
20	241	222	211	223

1/ No significant difference in yields.

Tests on dryland at Lubbock showed that both spacing and date of thinning produced differences (Table 2). In the plots thinned at stand date and 2 weeks later, the 10 and 15-inch spacing of plants made better yields, but after the second week, thinning of plants to spacings of 15 and 20 inches reduced yields.

Table 2. Pounds of lint per acre produced on dryland by cotton thinned to various spacings at stand date and later intervals, Lubbock, 1954

Spacing, inches	Stand date	Weeks after stand date		
	June 7	2	4	6
3	215	205	228	188
6	216	191	245	182
10	227	276	223	166
15	243	253	192	146
20	196	231	160	110
Mean[1/]	219	251	210	158

1/ Least significant difference at 5 percent level between means of dates of thinning = 72 pounds per acre.

In the irrigated test at Lubbock, thinning to a spacing between plants up to 20 inches at stand date and 1 week later did not influence yield, but later thinnings to the wider spacings decreased yields (Table 3).

Table 3. Pounds of lint per acre produced by irrigated cotton at different spacings and dates of thinning, Lubbock, 1954

Spacing, inches	Stand date June 7	Weeks after stand date 1	2	3	4	5	6
3	625	665	685	643	722	693	641
6	702	681	666	743	666	671	668
10	722	646	660	707	652	581	585
15	695	700	660	625	622	560	508
20	687	628	577	557	572	571	487
Mean[1/]	686	664	649	655	647	614	578

1/ Least significant difference at 5 percent level between means of dates of thinning = 45 pounds per acre.

Available information since 1926 indicates no great difference in the yield of cotton in Texas from stands varying from 13,000 plants per acre to several times more plants per acre. With the increased use of mechanical harvesters, farmers are advised to obtain higher plant populations which increase the efficiency of the machines. TAES Progress Report 1527 contains information on stripper efficiency in relation to stands.

Levels of Defoliation vs. Stages of Growth

Losses of leaf-blade tissue by hail vary from slight to total destruction of leaves. Defoliation tests were made to find the effects on yield from the loss of different amounts of leaf area under various growth conditions over the State. Plots were defoliated by hand to the extent that 0, 25, 50, 75 and 100 percent of leaves were removed. The first set of plots was defoliated 1 week after stand date, and separate sets of plots were defoliated similarly each week for 11 more weeks. Plant measurements were taken weekly to record plant growth stage.

The dryland experiment at College Station showed significant differences in levels of defoliation and in time of defoliation (Table 4). A small loss resulted from removing 50 and 75 percent of the leaves during the squaring and flowering period. Total defoliation at any time decreased yields, particularly during the peak of squaring and flowering.

Table 4. Pounds of lint per acre produced on plots defoliated to different degrees throughout the growing season, College Station, 1954

Date	Growth stage	Percent of leaves removed 0	25	50	75	100
May 3	1-2 leaves	145	159	167	148	119
May 17	4-5 leaves	165	146	129	148	139
May 31	1-2 squares	151	150	161	137	106
June 14	6-10 squares	147	145	130	157	112
June 28	1-2 flowers	142	150	134	116	58
July 12	1-3 bolls	141	144	123	135	110
Mean[1/]		149	149	141	140	107

1/ Least significant difference at 5 percent level between means of degress of defoliation = 15 pounds per acre.

Levels and time of defoliation were both significant in the irrigated test at Lubbock (Table 5). Removal of all leaves caused an appreciable reduction in yield at all dates. The loss was greatest at the height of flowering. Significant reductions of yield also resulted from removing 50 and 75 percent of the leaves during the peak of flowering. During the early part of the season the removal of 75 percent of the leaves did not decrease yield. Later in the season as young bolls were developing, some reduction in yield may have occurred from removing 25 percent of the leaves.

Table 5. Pounds of lint produced by irrigated cotton after plants had been defoliated to various degrees at intervals in the growing season, Lubbock, 1954

Date	Growth stage	Percent of leaves removed				
		0	25	50	75	100
June 14		598	665	664	653	522
" 21	Presquaring	642	696	612	555	413
" 28		707	609	688	620	500
July 5		642	622	638	638	511
" 12	Squaring	659	632	638	588	511
" 19		631	692	601	583	492
" 26		666	594	583	492	337
Aug. 2		688	644	605	514	333
Aug. 9	Peak of flowering	598	631	566	598	337
" 16		644	579	573	479	237
" 30		653	588	481	561	365
Sept.13		692	627	642	598	535
	Mean 1/	651	631	603	572	424

1/ Least significant difference at 5 percent level between means of levels of defoliation = 130.5 pounds per acre.

Topping

The tender terminal parts of a cotton plant are easily destroyed by hail. Tests were made to determine the effect of removing the terminal bud, which greatly influences the development of a cotton plant when intact. The terminal bud was removed from plants starting at stand date. Each week for a number of weeks other plants were topped.

The results in Tables 6, 7 and 8 show small if any reductions in each test except the dryland test at Lubbock. Although statistical analysis showed no significant difference, the reduction of about 20 percent over most of the period of the Lubbock dryland test may be real. Little effective rainfall was received after planting until mid-August. Moisture limited growth throughout the year, and under those conditions removal of the terminal bud is expected to cause the greatest reduction in yield of cotton.

Although there was a severe drouth at College Station, rain fell evenly enough in the early season to delay serious water stress in the plants until the first week in July. After the 10th of July, all growth and fruiting stopped and topping after that date could have had little, if any, effect. The difference in rainfall at Lubbock and College Station may explain the difference in results.

Table 6. Pounds of lint per acre produced after plants had been topped at intervals in the growing season, College Station, 1954

Date of topping	Yield[1/]	% of check	Remarks
Check	148		
May 3	103	69	
" 10	146	98	
" 17	141	95	
" 24	144	97	
" 31	146	98	
June 7	195	100/	Start of squaring
" 14	169	100/	
" 21	163	100/	Start of flowering
" 28	165	100/	
July 5	132	89	
" 12	143	97	
" 19	185	100/	
" 26	162	100/	
Aug. 2	173	100/	33% open

1/ No significant difference between treatments.

Table 7. Pounds of lint per acre produced by irrigated cotton after plants had been topped at intervals in the growing season, Lubbock, 1954

Date of topping	Yield[1/]	% of check	Remarks
Check	614		
June 14	511	83	
" 21	592	96	
" 28	609	99	
July 5	588	95	Start of squaring
" 12	511	83	
" 19	566	92	
" 26	581	94	
Aug. 2	555	90	
" 9	642	100/	
" 16	581	94	Peak of flowering
" 23	625	100/	
" 30	598	97	

1/ No significant difference between treatments.

Table 8. Pounds of lint per acre produced on dryland after plants had been topped at intervals in the growing season, Lubbock, 1954

Date of topping	Yield[1/]	% of check	Remarks
Check	221		
June 14	230	100/	
" 21	173	78	
" 28	255	100/	
July 5	179	81	
" 12	168	76	Start of squaring
" 19	164	74	
" 26	191	86	Start of flowering
Aug. 2	183	82	
" 9	177	80	
" 16	148	67	

1/ No significant difference between treatments.

Middle Cutoffs

Hail can sever the main stem of cotton any place from the ground-line to the terminal bud. The plant severed near the middle node is one of the most troublesome cutoffs from the standpoint of estimating recovery. This injury was simulated by cutting plants off at the middle joint starting 1 week after stand date and continuing the treatment on separate plots for a number of weeks.

Table 9 shows that early treatments at College Station caused significant losses, perhaps because of the slow rate of growth made by the plants near the point of water stress. The losses were greater at later dates.

Table 9. Pounds of lint per acre produced after plants had been cut off at the middle joint at intervals in the growing season, College Station, 1954

Date cut	Yield[1/]	% of check
Check	168	
May 3	120	71
" 10	111	66
" 17	114	68
" 24	95	56
" 31	106	63
June 7	94	56
" 14	90	53
" 21	84	50
" 28	57	34
July 5	76	45
" 12	56	33

1/ Least significant difference at the 5 percent level = 31 pounds per acre or 18 percent.

The results of the dryland and irrigated tests at Lubbock are shown in Tables 10 and 11.

Table 10. Pounds of lint per acre produced on dryland after plants had been cut off at the middle joint at intervals in the growing season, Lubbock, 1954

Date cut	Yield[1/]	% of check
Check	267	
June 21	276	100/
" 28	281	100/
July 5	257	96
" 12	219	82
" 19	213	79
" 26	183	68
Aug. 2	74	27
" 9	46	17

1/ Least significant difference at the 5 percent level = 37 pounds per acre or 14 percent.

Table 11. Pounds of lint per acre produced by irrigated cotton after plants had been cut off at the middle joint at intervals in the growing season, Lubbock, 1954

Date cut	Yield[1]	% of check	% open Nov. 1
Check	775		95
June 21	762	98	95
" 28	750	96	95
July 5	762	98	95
" 12	687	88	70
" 19	612	79	70
" 26	587	75	80
Aug. 2	462	59	50
" 9	462	59	90
" 16	362	46	95

1/ Least significant difference at the 5 percent level = 166 pounds per acre or 21 percent.

No real reductions in yield occurred from the treatments until after the first week of July. In applying the injury the fruiting structures below the joint of severance were left undamaged. In early season, when there are no fruiting forms, the damaged plant simply regrows from buds below the cut. However, later in the season continued vegetative growth seems to be hindered by young bolls below the point of severance. Where several young bolls are present, there is no further vegetative growth except that associated with the maturing of these bolls.

Bottom Cutoffs

Cotton plants can be cut off near the ground level by large wind-driven hailstones, as occur in severe spring hailstorms. Plants cut off below the lowest joint or cotyledonary node cannot recover; plants cut off just above the cotyledonary node still have two buds which can grow and can produce a full-sized plant. To measure the recovery from such an injury, plants were cut off just above the cotyledonary node starting 1 week after stand date. Each week thereafter for a number of weeks other plants were treated in the same manner.

The results are shown in Tables 12, 13 and 14. The results of the irrigated and dryland tests at Lubbock are similar.

Table 12. Pounds of lint per acre produced on dryland after plants had been cut off just above cotyledonary node at intervals in the growing season, Lubbock, 1954

Date cut	Yield[1]	% of check
Check	241	
June 21	255	100/
" 28	233	96
July 5	225	93
" 12	195	80
" 19	99	40
" 26	79	32
Aug. 2	0	0

1/ Least significant difference at the 5 percent level = 12 pounds per acre or 5 percent.

Decreases of yield were not significant until after the first week of July. However, in terms of maturity, any such damage after the last week of June might result in much greater losses in years when the fall weather is unfavorable for maturing of bolls.

Table 13. Pounds of lint per acre produced by irrigated cotton after plants had been cut off just above cotyledonary node at intervals in the growing season, Lubbock, 1954

Date cut	Yield[1]	% of check	% open
Check	696		95
June 22	650	93	95
" 29	602	86	95
July 5	596	85	33
" 12	406	58	5
" 19	250	35	0
" 26	0	0	0

1/ Least significant difference at the 5 percent level = 152 pounds per acre or 21 percent.

The results at College Station are variable, but show that cotton can recover from such injuries when inflicted in early season. Plants cut off after May 31 at College Station recovered, but the late summer drouth caught them at the flowering stage and they did not produce any cotton.

Table 14. Pounds of lint per acre produced after plants had been cut off just above cotyledonary node at intervals in the growing season, College Station, 1954

Date cut	Yield[1]	% of check
Check	194	
May 10	143	74
" 17	183	94
" 24	156	80
" 31	65	33
June 7	0	0

1/ Least significant difference at the 5 percent level = 59 pounds per acre or 30 percent.

Complete Stripping

Hail seriously damages cotton by completely stripping the stalk of limbs, leaves and fruiting parts. Usually a severe storm also destroys the bark on one side of the stem. These conditions were simulated by complete stripping of plants starting at the appearance of squares and continuing for several weeks on separate plots of plants. Damage to the bark was inflicted by holding the top part of the plant and stripping the lower part with a downward motion. The treatment was completed by stripping with an upward motion to remove upper limbs, leaves and the terminal bud. The results of these experiments, both irrigated and dryland at Lubbock, are shown in Tables 15 and 16.

Table 15. Pounds of lint per acre produced on dryland after plants had been stripped at intervals in the growing season, Lubbock, 1954

Date stripped	Yield	% of check
Check	195	
July 5	83	42
" 12	87	44
" 19	74	37
" 26	50	25

Table 16. Pounds of lint per acre produced by irrigated cotton after plants had been stripped at intervals in the growing season, Lubbock, 1954

Date stripped	Yield	% of check	% open Nov. 1
Check	639		95
July 5	367	57	40
" 12	288	45	10
" 19	100	15	0
" 26	76	11	0
Aug. 2	21	3	0

No analysis of these data was made because of the large differences. In spite of the large decreases in yield, the recovery of the plants from injuries of such severity indicates that the cotton plant has unusual regenerative abilities.

Combinations of Injuries

Hail damages several parts of a cotton plant. Two tests, one at Lubbock and one near Ralls, were made to find whether the effect of combined injuries is a linear or differential response. Four levels of defoliation and other types of injury were combined at distinguishable stages of growth. Plans were to treat plants at 15 days after emergence, start of squaring, start of flowering and two to three young bolls. However, plants were treated only three times at Ralls because of a heavy thrip infestation which delayed fruiting and either destroyed buds or hindered normal growth of terminal buds.

The results are shown in Tables 17 and 18 and are expressed as the percentage of the mean of all checks. Table 19 contains the statistical results at the two locations.

Table 19 shows the several interactions and the magnitude of their mean square. The interactions of defoliation with growth stage and type of injury were not significant at Ralls. The relatively small mean square for these interactions resulted from the late fruiting.

The mean squares for main effects (defoliation, growth stage and types of injury) are relatively quite large and account for a major part of the variation.

Decreases in yield from defoliation are mainly due to 100 percent defoliation, although it appears that 33 and 66 percent defoliation contributed to the reduction, especially at Lubbock (Tables 17 and 18).

Table 17. Yields as percent of the mean of all checks resulting from combinations of defoliation and other injuries at different stages of growth, Pearson farm, Ralls, 1954

% of leaves removed		Type of additional injury			
		Undamaged	Topped	Middle cutoff	Stripped of fruiting limbs
0	June 22	98	90	82	88
	July 12	109	92	66	90
	Aug. 11	92	98	39	33
33	June 22	93	92	80	89
	July 12	95	78	64	77
	Aug. 11	94	82	32	43
66	June 22	97	96	79	104
	July 12	99	92	63	80
	Aug. 11	83	83	38	35
100	June 22	75	49	34	80
	July 12	84	70	44	26
	Aug. 11	60	52	14	0

Table 18. Yields as percent of mean of all checks resulting from combinations of defoliation and other injuries at different stages of growth, Lubbock, 1954

% of leaves removed		Type of additional injury			
		Undamaged	Topped	Middle cutoff	Stripped of fruiting limbs
0	June 21	97	94	65	84
	July 5	102	88	74	87
	" 23	100	93	63	86
	Aug. 6	101	109	49	70
33	June 21	100	93	64	100
	July 5	90	86	74	84
	" 23	91	85	50	64
	Aug. 6	81	78	37	65
66	June 21	90	88	67	82
	July 5	88	85	65	86
	" 23	84	79	52	58
	Aug. 6	72	73	28	54
100	June 21	76	52	48	82
	July 5	67	72	50	39
	" 23	63	62	29	7
	Aug. 6	40	40	10	4

There was a different response at the different stages of growth, particularly when the added injury was a middle cutoff or removal of fruiting limbs. Also, 100 percent defoliation caused a greater decrease at advanced growth stages. The large mean square for types of injury can be attributed to the middle cutoffs and stripping of fruiting limbs. Topping alone contributed very little.

Table 19. Analysis of variance of yield

Source of variation	Lubbock Df.	Lubbock Mean square	Ralls Df.	Ralls Mean square
Reps	3		3	
Defoliation	3	42.99[1]/	3	24.63[1]/
Error "a"	9	1.38	9	0.15
Growth stage	3	17.02[1]/	2	31.75[1]/
Def. x g.s.	9	1.87[1]/	6	0.39
Error "b"	36	0.57	24	0.40
Type injury	3	32.57[1]/	3	31.27[1]/
Type injury x def.	9	0.78[1]/	9	0.32
Type injury x g.s.	9	2.23[1]/	6	6.09[1]/
Type injury x g.s. x def.	27	0.61[1]/	18	0.84[1]/
Error "c"	144	0.21	108	0.17

1/ F significant at 1 percent level.

The interactions of dedoliation x growth stage, defoliation x type of injury, growth stage x type of injury and the triple interaction are significant. These resulted primarily from the differential response of the last two types of added injury with both defoliation and growth stage. Topping added little to the decrease caused by defoliation alone.

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