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Regrowth of Australian Cotton Varieties After Damage By Hail

CDL1C

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Prepared as a Final Report
for the
Cotton Research and Development Corporation

by
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Final Report

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Field of Research: Cultivar Evaluation **Field Code:** 3.3

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Project Objectives:

(i) To quantify and compare the regrowth characteristics of cotton varieties, following simulated hail damage at various stages of plant development.

(ii) In co-operation with the industry's loss adjusters, modify the loss assessment procedures to provide a more accurate reflection of losses to growers and if appropriate make varietal recommendations for high hail risk areas.

CONTENTS

Summary:

In 1990, a Cotton Research and Development Corporation funded project was begun, in co-operation with the Industry Hail Scheme Insurers, to evaluate the growth response after hail damage, of cotton varieties currently grown in the Australian cotton industry. The regrowth of varieties after simulated hail damage was investigated in a series of trials carried out over three cotton seasons. Australian-bred varieties, currently grown, were compared to the U.S. bred variety, Deltapine 90. Growth responses were measured in terms of final lint yield, delayed maturity and changes in lint quality. It was found that although there are observed differences between varieties in the rate of regrowth of vegetative material and in the rate of square production following simulated damage, hail did not affect the lint yield of varieties differentially. Date of damage and level of damage were found to be the major contributing factors to yield loss. Seasonal effects such as season length were examined to determine the effect on the lint yield of varieties, and from this it was determined that hail damage will not produce a difference in lint yield between varieties as long as the each variety is allowed to go through to maturity This is not the case in 'normal commercial cotton production' where total farm management or the climatic character of an area impose restrictions on the regrowth of one variety in comparison to another and hence can induce a difference in final lint yield. From this data, loss adjustment procedures are to be modified by the overlaying of damage date and season length to take into account the effect of damage date as measured in this work. Varietal recommendations for high hail risk areas cannot be made on the basis of differing ability of varieties to regrow after hail but should be made on the basis of the suitability of a variety for a cotton production of the specified average season length, with management strategies imposed following damage to ensure that the variety fully matures in the remaining available growing season.

Background and Industry Significance:

Insurance claims for cotton damaged by hail in the previous five years are estimated at $35 million . The total loss to the cotton industry could be estimated at $60 million, if you take into account the potential yield of the damaged crops and the prices of the day. The losses are borne by both the individual growers who lose their crop and by the industry as a whole, who pays higher insurance premiums

In 1990, the Cotton Research and Development Corporation funded this project to investigate and evaluate the effect of hail damage on cotton varieties currently grown in the Australian cotton industry. The research will improve our understanding of how the cotton plant responds to hail damage and may also identify better management practices to maximise recovery and importantly, it will allow the cross-checking of the loss assessment procedures currently used to assess Australian cotton varieties.

The loss assessment procedures used for the Industry Hail Scheme, which have been in use for over ten years, are based on the Acala lines of cotton grown under North American conditions. With the introduction of Australian-bred varieties to the Australian industry in the 1980s, and well documented and observed differences in plant growth between varieties, it was considered an appropriate time to find out how these varieties respond to hail damage.

Therefore, the aim of this work was to compare the regrowth characteristics of Australian cotton varieties after hail damage at various stages of plant development and in co-operation with the Industry Hail Loss Adjusters, update the loss assessment procedures to ensure growers losses are accurately reflected.

Dissemination of Results:

Results of this work will be made available to the Industry Loss Adjusters, for use in updating and / or modifying the current loss adjustment procedures. The work forms part of a Master's Degree thesis for the principal researcher which will be published in full by July, 1995. Initial findings were presented to the cotton industry at the 1992 Australian Cotton Conference and were published in the proceedings of the conference. Final results will be presented in cotton industry publications and hail insurance industry presentations.

Difficulties Encountered:

The project was contracted out to the principal researcher nine months into the project. This effectively cut the 'network' of contacts or assistance available to the principal researcher. It is believed that industry funded projects are more effectively run from within an organisation tied to agricultural research rather than isolated from it, such can be the case with the use of an independent researcher. The problem has now been alleviated for the course of a newly funded related project investigating the management of cotton after hail damage. The C.R. & D.C. and Department of Agriculture at Narrabri Agricultural Research Station have arranged for lease of office space at the Narrabri Agricultural Research Station for the principal researcher which enables closer contact or ties with other researchers in cotton.

Recommendations for Further Research:

The current hail insurance scheme is based on a system which reimburses production costs to growers for production to the time of damage. The grower must then decide what to do with the crop to maximise his economic returns.

If the grower requires to continue with the crop, there are no guidelines in place as to what constitutes 'good crop management' following hail damage. This work has shown that variety is only important in areas where season length or disease susceptibility disadvantages a variety. So, for a damaged crop, which management strategies have the highest cost/benefit ratio, when such factors as water, insect management, growth regulators and harvesting of damaged crops is taken into account? How can damage assessment be improved?

It is suggested that whilst the current insurance system is in place, future research should investigate the agronomic factors of importance following hail with the aim of developing a list of criteria with which to assist growers in making a decision on whether to carry on with a crop following a hail strike.

Note: This recommendation was the subject of a research project proposal submitted to the Cotton Research and Development Corporation for consideration for funding in February, 1993 and subsequently funded as Project No.CDL3C - Management of Cotton Following Damage by Hail.

Acknowledgments:

In carrying out this project, I have been fortunate in receiving the assistance of cotton growers in the Namoi Valley who have allowed me to carry out large scale trials in their commercial cotton fields. The late Mr Richard Williams of "Merinda" Myall Vale and then Mr David Revell of "Jungaburra" Wee Waa provided large scale trial sites on "Merinda West" Myall Vale. Auscott Ltd, Narrabri not only provided trials sites over the three years of the program but also provided their expertise and man-power for building of the hail simulation unit and in carrying out hail simulation treatments and I would like to thank Mr David Anthony and Mr Bob Bell, in particular for their assistance. Auscott also assisted in the work by carrying out the fibre quality testing of trial lint samples.

Small scale trials were carried out during 1991/92 and 1992/93 seasons at the Narrabri Agricultural Research Station with the co-operation of the Department of Agriculture and the C.S.I.R.O. and in particular, Mr Russell Martin and Dr Greg Constable.

Ginning facilities, transport and office facilities were supplied by Cotton Seed Distributors Ltd, Wee Waa and their assistance is appreciated.

Research Program and Trial Methods:

1. Site Selection and Trial Size

Previous work carried out by Robins Agriculture Pty Ltd had shown the difficulty of maintaining uniformity of damage with manual simulation of hail damage and hence, large scale trials were chosen to allow the simulation of damage by mechanical means. Commercial scale trials were planted at two Namoi Valley sites for each of the three years of the program.

To reduce the risk of having to abandon a trial due to the occurrence of natural hail across a site, it was decided to replicate the large scale trial on sites at two locations with a suitable distance between sites to reduce the chances of loss of both sites whilst remaining within a serviceable area for movement of machinery.

After collation of year one data it was determined that a small scale trial was required to validate trial results generated in the large scale trailing. Hence, a intensively sampled small scale trial was planted in year two and three on the Narrabri Agricultural Research Station, Myall Vale.

Field selection criteria were uniformity of soil type and land development, with uniform water flow and drainage and no anticipated problems with the application of insecticides. Trials were situated within selected fields with sufficient buffer crop from the side of fields and a suitable distance from head and tail ditches to remove any effects of back-up water etc during irrigation.

According to McGarry, Ward and McBratney in their study of the soils of the Lower Namoi Valley, the Narrabri Agricultural Research Station trial site soil is a grey clay (Ug5.15) as were the Auscott Narrabri sites in 1990/91 and 1992/3. The Auscott site in 1991/92 was again a grey clay but situated closer to the river was classified as Ug6.2 The Merinda sites at "Carson's" and "Merinda West" were brown clays (Ug5.15)

(Ref: "Soil Studies in the Lower Namoi Valley: Methods and Data 1: The Edgeroi Data Set"
C.S.I.R.O. Division of Soils
D. McGarry, W.T. Ward and A.B. McBratney 1989)

Large scale trial size was determined by machinery set-up and size. Our aim was to carry out a commercial size trial for the direct translation of trial results to the commercial situation. Hence, with tractor rig width of eight rows (ie. 8 metres), plots were to be 8 metres wide. A plot length of 15 metres was allowed giving 10 metres actual assessed plot length, one metre buffer at each end of the plot and an extra 3 metres for tractor movement and walkways.

The "commercial" NCIS assessments require 10 feet of row length per assessment. Damage simulation was only carried out over the central four rows of each plot.

The small scale trial was limited by the plot size manageable in terms of manual infliction of hail simulation. Plot size was 5m x 5m in length. Damage simulation was carried out over the entire plot area whilst fruit and yield estimates and damage assessments were carried out in buffered central rows of each plot.

2. Varieties

Varieties were selected on the basis of their commercial value to the cotton industry and their expected commercial value. Representative varieties were selected from the major groups of varieties. In the small scale trial, Deltapine 90 being the hail standard was used as the base variety and compared against Siokra 1-4. Siokra 1-4 being the current Australian industry standard.

In the large scale trials, Sicala 33 and Siokra L22. were also included , with Sicala 33 selected as it represents the higher quality lines which currently represent approximately 20% of plantings, and Siokra L22 is the most exciting of the newly released lines having a very high yield potential and good quality characteristics and has rapidly taken a large slice of the market. ie. a total of four varieties were used in the large scale trials. Sicala 33 was replaced by Sicala 34 in the 1992/93 trials as Sicala 34 superseded Sicala 33 commercially.

3. Hail Simulation

In the small scale trial, all damage simulations were carried out by manual means to achieve the most accurate simulation and proportional representation of symptoms with a moderate level of damage (50%) chosen as the treatment level..

Actual date of hail simulation depends on crop development rate which of course is Day Degree dependent. Damage was timed to coincide with early vegetative, late vegetative, early reproductive (or mid flowering) and late reproductive (or boll fill/maturation) stages of plant development. In relation to the N.C.I.S. procedures, the dates of damage related to the V3, V5, R8/R9 and R12+ stages of development.

Vegetative stage damage involves mainstem cutoffs and stand reduction due to cut-offs occurring below the cotyledons. Calculations were made to provide a percentage of plants to be killed and percent plants to be damaged by CC, C1 or C2 cut-offs which together provided a total damage inflicted of 50%. Cut-offs being inflicted using secateurs and foliage removal being inflicted by use of a garden rake.

In the reproductive stage, damage is represented by a combination of symptoms including mainstem cut-offs and bruising, fruiting limb cut-offs and bruising, square removal, boll damage and removal. To simulate damage in the reproductive stage by manual means, calculations were made to provide an average position of mainstem cut-off, average number of fruiting limbs to be removed per plant. Damage to bolls was summed to whole boll equivalents and whole boll equivalents were removed. These combined with a raking of the plants to remove/damage foliage and remove squares produced the required levels of damage at the two reproductive stages of damage.

Damage was simulated in the large scale trials using the simulation rig developed for the 1990/91 season with modifications for 1991/92 and 1992/93 allowing for improved control of the unit. Rig width was decreased to four rows to decrease swaying and vertical movement of the unit during use and hence allowing for more uniform damage across a plot. The hydraulic drive was changed to a hydraulic driven gear box to improve the accuracy of maintaining r.p.m. of the unit down a plot.

Damage simulation by wholly mechanical means cannot reproduce all symptoms of "natural hail damage". A review of the 1990/91 trial results showed that the most representative symptoms were achieved using a combination of mechanical and manual means.

Hence, for the second two years of trial work, the simulation unit was used to inflict damage in the vegetative stages where damage consists primarily of stem cut-offs and foliage removal. Once the crop entered the reproductive phase, damage was simulated using the unit at low speed to inflict stem damage and foliage removal, and following through with secateurs and electrical conduit to manually inflict fruiting branch damage and damage or removal of bolls.

In the 1991/92 season, climatic conditions in the Namoi Valley saw a rapid and short flowering period followed by an early cutout. The crop matured very quickly and hence the late reproductive damage was inflicted at the R12+ stage and electrical conduit alone was used to inflict this damage.

For the large scale trials, damage simulation aimed for average damage levels of 30% and 60% percent, selected to represent moderate and severe levels of hail damage. Actual achieved damaged levels being commercially assessed by Robins Agriculture Pty Ltd. using the N.C.I.S. loss assessment procedures.

Actual damage dates and growth stages at those dates are summarised in Appendix A.

4. Regrowth Monitoring and Yield Loss Determinations

Fruit development and vegetative regrowth was measured throughout the season by fruit counts and plant height monitoring (See Appendix B). At the end of the season, sequential hand picking of sample areas at 7-10 day intervals was used to determine any delay in maturity due to simulated hail damage (See Appendix C).

Overall final lint yield was determined by a mechanical pick using a single row cotton picker, for a 10 metre square (10 metre length of row). Quality testing was carried out on lint samples from final yield picks by Auscott Ltd as per their commercial quality testing.

In the case of the small scale trial, more intensive sampling was required. Fruit counts were carried out over one metre row lengths at weekly intervals. At the same time, leaf areas were measured (indirectly via light intensity readings) per metre of row. Sequential hand picking was carried out as per the large scale trials. Final plot yields were obtained from the summation of individual sequential pick lint yields.

Results and Conclusions:

Climatic Patterns 1990/91 to 1992/93

All three trial sites are within the area normally serviced by the Narrabri Agricultural Research Station weather station at Myall Vale. Data covering the three year period is presented in Appendix D: Climatic Data.

In general, 1990/91 was a warm season with above average maximum temperatures for each month of the season.(Climatic Table No.1)

Correspondingly, heat unit accumulation remained higher than the average for the entire season. Rainfall was moderate overall, with a dry and warm November allowing good stand establishment and a dry April providing good picking conditions with both trials being picked before the unusually high rainfall of May occurred. (See Climatic Graph No.1 & 2.)

Rain interrupted many operations in the 1991/92 season although temperatures were average to slightly above average for each month. After a warm and dry start to the season and good stand establishment, heavy rain occurred in December during peak squaring and then again in February during late squaring/boll fill. (See Climatic Table No.2 and Climatic Graph Nos. 3 & 4). The effect of Verticillium wilt was increased at the Auscott Narrabri site due to these conditions which promote verticillium development. Leaf development and square retention were affected by these periods of overcast weather. January was a period of warm clear weather and rapid reproductive development was observed during this period. The short boll setting period resulted in a short and rapid boll opening period.

1992/93 began with a cool start and slow establishment. This is reflected in the crop regrowth following vegetative stage hail simulations. From January conditions improved with little rain and warm temperatures experienced for the remaining part of the season. Indeed although temperatures and relative humidity averaged over January and February were not extraordinarily high, two three weeks of very temperatures and high humidity were recorded. A dry April allowed for good picking conditions. (See Climatic Graph No.3 and Tables 5 & 6).

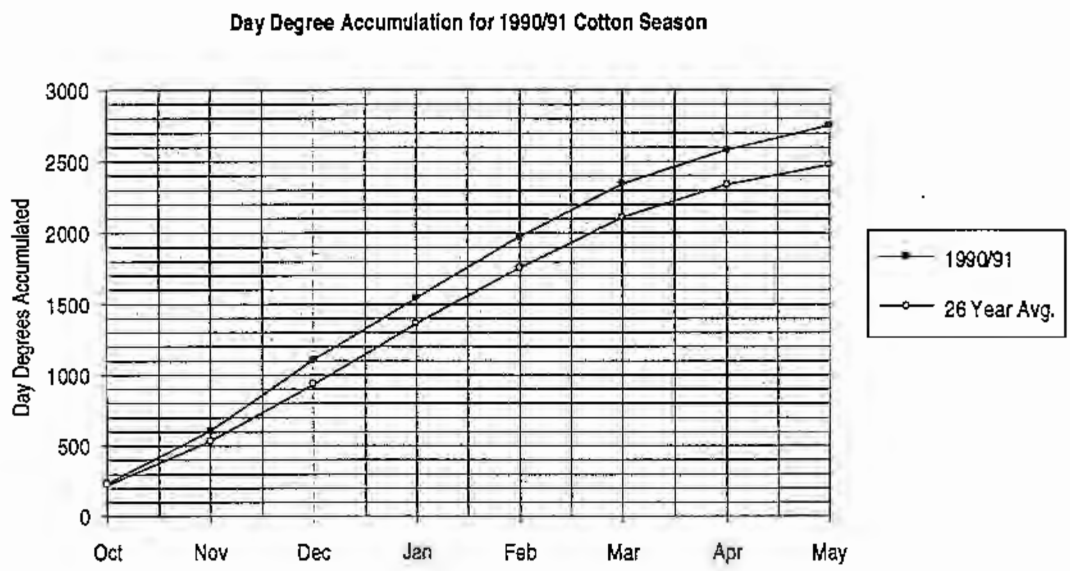
Climatic Table No.1

Summary of Weather Data for Cotton Season 1990/91

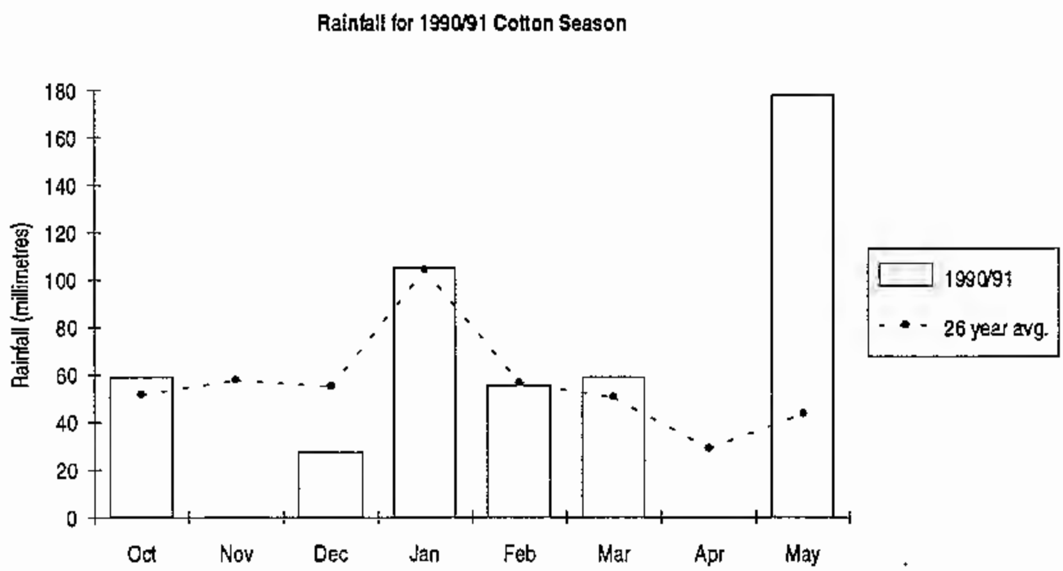
Month	Rain (mm)		Max Temp (^0C)		Min Temp (^0C)		Radn (Langley)		Soil Temp (^0C)		RH (%)		Day Degrees		Accumulated Day Degrees	
Oct	58.8	(51.4)	26.1	(25.9)	11.3	(12)	529	(493)	15.6	(17.6)	52	(57)	234	(223)	234	(223)
Nov	0.2	(57.5)	32.4	(29.5)	16.1	(15.1)	638	(570)	17.6	(21.3)	57	(53)	368	(308)	602	(531)
Dec	27.2	(54.7)	36.1	(32.2)	20.4	(17.8)	642	(605)	19.6	(24.4)	40	(54)	504	(403)	1106	(934)
Jan	104.8	(103.9)	32.6	(32.5)	19.6	(19.2)	555	(590)	23.6	(25.6)	47	(60)	437	(430)	1543	(1364)
Feb	55.4	(56.6)	34.2	(32.5)	20.5	(19.3)	576	(547)	23.9	(25.5)	54	(63)	430	(390)	1973	(1754)
Mar	58.8	(50.2)	32	(30.1)	15.6	(16.8)	519	(484)	21.2	(23.2)	46	(62)	372	(355)	2345	(2109)
Apr	0	(28.7)	26.9	(26.4)	10.3	(12.2)	425	(380)	18	(18.8)	46	(63)	236	(228)	2581	(2337)
May	177.8	(43.5)	22.4	(21.2)	11	(7.9)	275	(278)	15.6	(14.1)	65	(70)	170	(142)	2751	(2479)
	Total		Avg.		Avg.		Total		Avg.		Avg.		Total			
	483	(446.5)	30.33	(28.7)	15.6	(15.0)	4159	(3947)	19.388	(21.3)	50.875	(60.3)	2751	(2479)		

* In brackets is presented the 26 Year Average

Climatic Graph No.1



Climatic Graph No.2



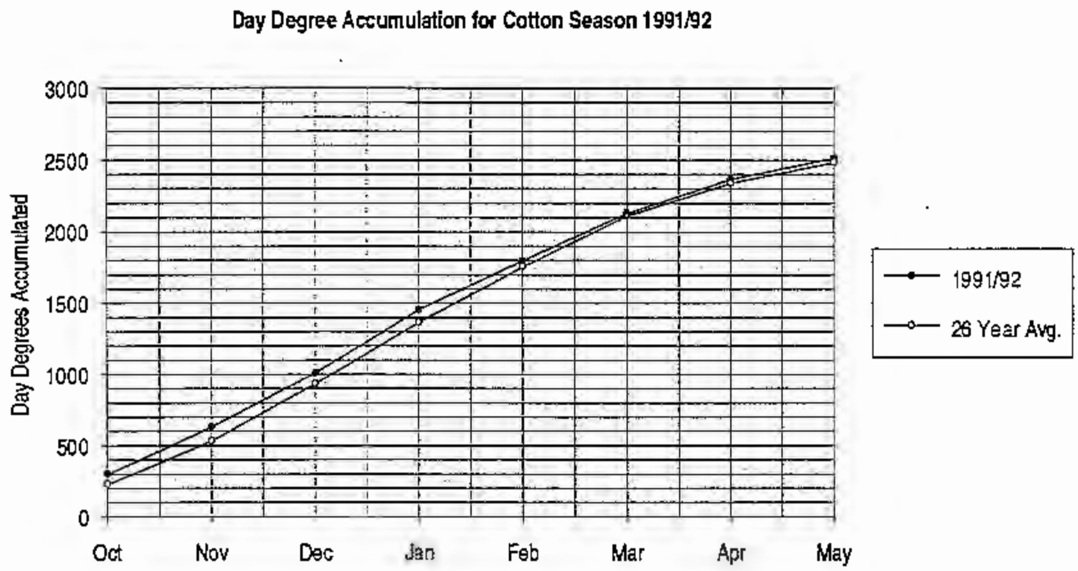
Climatic Table No. 2

Summary of Weather Data for Cotton Season 1991/92

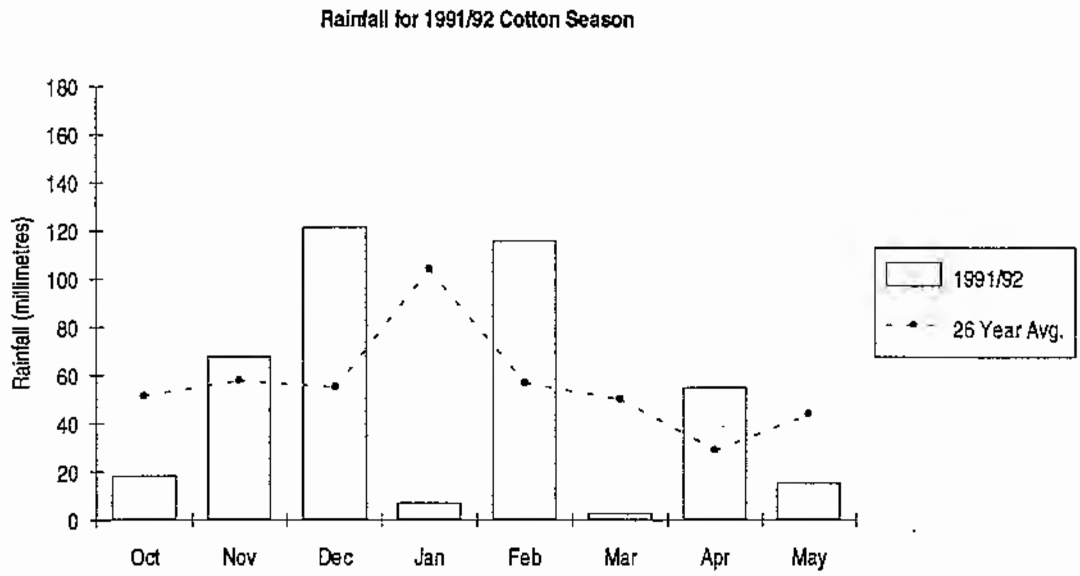
Month	Rain (mm)		Max Temp (^{0}C)		Min Temp (^{0} C)		Radn (Langley)		Soil Temp (^{0}C)		RH (%)		Day Degrees		Accumulated Day Degrees	
Oct	18	(51.4)	29.2	(25.9)	13.2	(12)	534	(493)	16.4	(17.6)	44	(57)	294	(223)	294	(223)
Nov	67.4	(57.5)	30.1	(29.5)	16.3	(15.1)	547	(570)	18.7	(21.3)	48	(53)	336	(308)	630	(531)
Dec	121.4	(54.7)	30.9	(32.2)	17.5	(17.8)	593	(605)	19.9	(24.4)	47	(54)	378	(403)	1008	(934)
Jan	7	(103.9)	34	(32.5)	18.7	(19.2)	617	(590)	21.7	(25.6)	45	(60)	445	(430)	1453	(1364)
Feb	115.4	(56.6)	30.4	(32.5)	17.4	(19.3)	495	(547)	20.7	(25.5)	63	(63)	345	(390)	1798	(1754)
Mar	2.6	(50.2)	30.9	(30.1)	14.1	(16.8)	510	(484)	19	(23.2)	59	(62)	331	(355)	2129	(2109)
Apr	54.6	(28.7)	26.9	(26.4)	11.3	(12.2)	359	(380)	15	(18.8)	65	(63)	235	(228)	2364	(2337)
May	15.2	(43.5)	21.6	(21.2)	8.2	(7.9)	271	(278)	10.6	(14.1)	67	(70)	149	(142)	2513	(2479)
	Total		Avg.		Avg.		Total		Avg.		Avg.		Total			
	401.6	(446.5)	29.25	(28.8)	14.588	(15.1)	3926	(3947)	17.75	(21.3)	54.8	(60)	2513	(2479)		

* In brackets is presented the 26 year average.

Climatic Graph No.3



Climatic Graph No.4

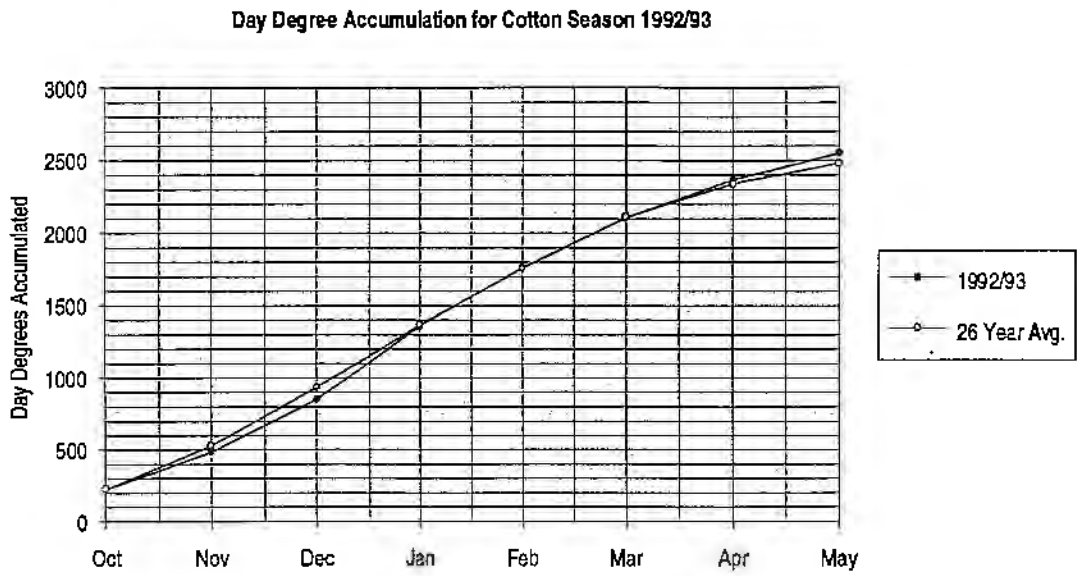


Climatic Table No. 3

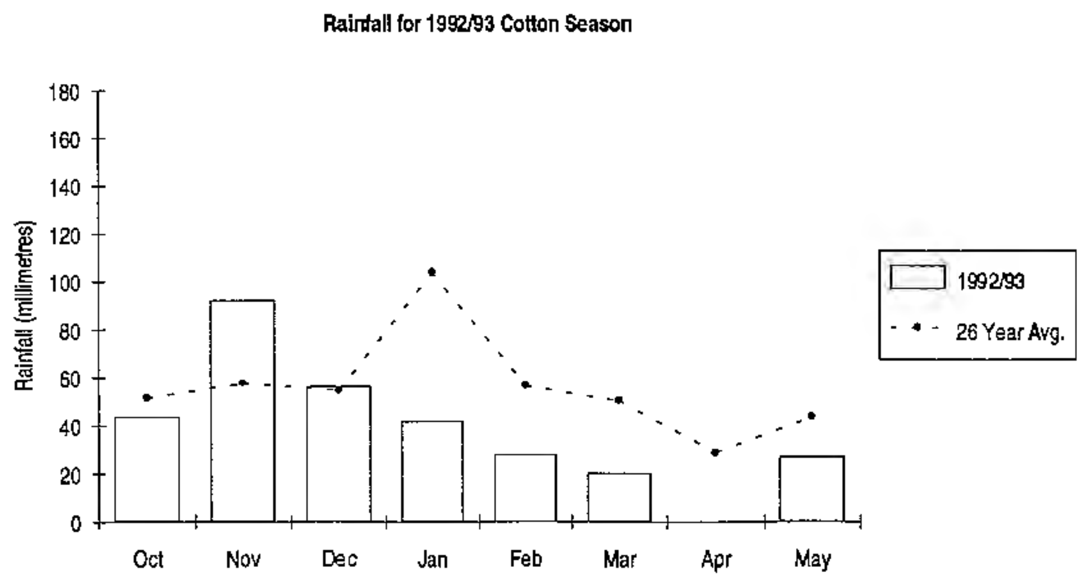
Summary of Weather Data for Cotton Season 1992/93

Month	Rain (mm)		Max Temp (^0C)		Min Temp (^0C)		Radn (Langley)		Soil Temp (^0C)		RH (%)		Day Degrees		Accumulated Day Degrees	
Oct	43.5	(51.4)	25.3	(25.9)	10.7	(12)	496	(493)	16.4	(17.6)	54	(57)	223	(223)	223	(223)
Nov	92.1	(57.5)	27	(29.5)	13.6	(15.1)	551	(570)	19.4	(21.3)	52	(53)	261	(308)	484	(531)
Dec	56.2	(54.7)	29.9	(32.2)	17.7	(17.8)	553	(605)	21.5	(24.4)	58	(54)	366	(403)	850	(934)
Jan	41.7	(103.9)	35.3	(32.5)	21.6	(19.2)	618	(590)	23	(25.6)	65	(60)	510	(430)	1360	(1364)
Feb	27.6	(56.6)	33.3	(32.5)	19.3	(19.3)	574	(547)	22.3	(25.5)	65	(63)	402	(390)	1762	(1754)
Mar	20.1	(50.2)	29.9	(30.1)	15.8	(16.8)	507	(484)	20.4	(23.2)	63	(62)	341	(355)	2103	(2109)
Apr	0	(28.7)	28.4	(26.4)	12.2	(12.2)	384	(380)	15.4	(18.8)	56	(63)	262	(228)	2365	(2337)
May	27	(43.5)	23.2	(21.2)	9.5	(7.9)	276	(278)	13.2	(14.1)	69	(70)	184	(142)	2549	(2479)
	Total	Total	Avg.	Avg.	Avg.	Avg.	Total	Total	Avg.	Avg.	Avg.	Avg.	Total	Total		
	308.2	(446.5)	29.038	(28.8)	15.05	(15.0)	3959	(3947)	18.95	(21.31)	60.3	(60.3)	2549	(2479)		

Climatic Graph No. 5



Climatic Graph No.6

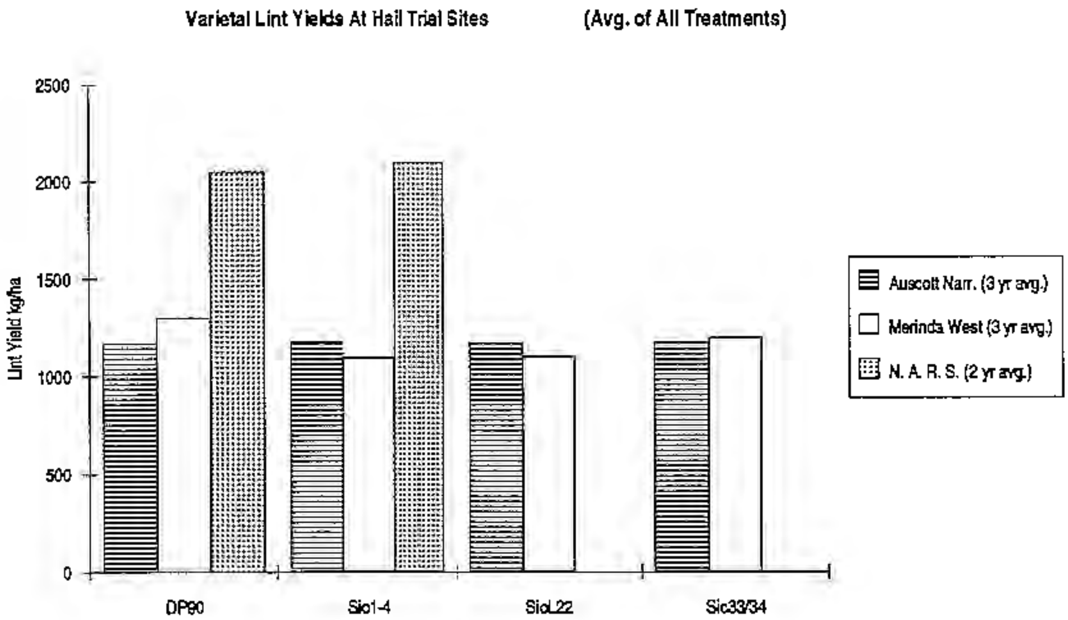


Lint Yield Trends for Varieties at Hail Trial Sites

Although the trials were carried out within the same climatic areas, soil types and agronomic management differ between trial sites and so it is necessary to analyse data from each site separately and then compare overall trends between sites. Data presented averages three years of trials for the large scale trials on Auscott Narrabri and Merinda West and two years of data for the Narrabri Agricultural Research Station.

Looking at the overall performance of varieties with respect to lint yield, there is little difference in lint yield potential between varieties tested. (See Lint Yield Graph No.1)

Graph No.1



Subdividing this data into the separate years of trailing, some moderately significant differences in lint yield were measured in the different seasonal conditions. (Lint Yield Table No.1)

At Auscott Narrabri in 1990/91, Siokra 1-4 and Siokra L22 yielded similarly with Siokra 1-4 out yielding DP90 by 9.2% and Siokra L22 out yielding DP90 by 15% (5% level of significance). The varieties out yielded Sicala 33 by 5.2% and 12.2% respectively. Siokra L22 is a longer season variety not usually suited this area, but the longer season experienced in 1990/91 allowed the variety to fully mature and out yield the moderate season varieties. No significant differences were measured in the following two years of trials.

Lint Yield Table No.1

Varietal Lint Yields For Simulated Hail Damage Trials

		Deltapine 90 kg/ha (ba/ha)	Siokra 1-4 kg/ha (ba/ha)	Siokra L22 kg/ha (ba/ha)	Sicala 33/34 kg/ha (ba/ha)		
Auscott Narrabri	1990/91	1470 (6.53)	1605 (7.13)	1733 (7.70)	1522 (6.76	**	l.s.d. = 140.54 kg
	1991/92	736 (3.27)	750 (3.33)	712 (3.16)	759 (3.37)		
	1992/93	1295 (5.76)	1168 (5.19)	1068 (4.75)	1253 (5.57)		
	Avg.	1167 (5.19)	1174.33 (5.22)	1171 (5.20)	1178 (5.24)		
Merinda West	1990/91	1027 (4.56)	870 (3.87)	857 (3.81)	1007 (4.48)	*	l.s.d. = 106.27kg
	1991/92	1508 (6.70)	1189 (5.28)	1403 (6.24)	1334 (5.93)	*	l.s.d. = 224.30kg
	1992/93	1356 (6.03)	1230 (5.47)	1045 (4.64)	1247 (5.54)		
	Avg.	1297 (5.76)	1096.33 (4.87)	1101.67 (4.90)	1196 (5.32)		
Narrabri Ag.	1991/92	2152 (9.56)	2114 (9.40)				
Research Station	1992/93	1945 (8.64)	2083 (9.26)				
	Avg.	2048.5 (9.10)	2098.5 (9.33)				

* 5% Level of Significance ** 0.1% Level of Significance

Differences in the performance of varieties was more enhanced at "Merinda West". On the "Carson's" field in 1990/91 the broad leaf varieties DP90 and Sicala 33 were found to out yield the okra leaf types (10% level of Significance). DP90 and Sicala 33 yielded similarly and both out yielded Siokra 1-4 and Siokra L22 by 13.6 - 16.6 %. In 1991/92, DP90 again produced the top lint yield at "Merinda West" although not significantly higher than Siokra L22 or Sicala 33. Siokra 1-4 showed a significantly decreased yield (10% level of significance) yielding 10.9 to 21.2% lower than the other varieties. No differences between varieties was found in 1992/93.

At Narrabri Agricultural Research Station lint yields were higher than both large scale trial sites and shown no difference in yield potential between DP90 and Siokra 1-4 for this site.

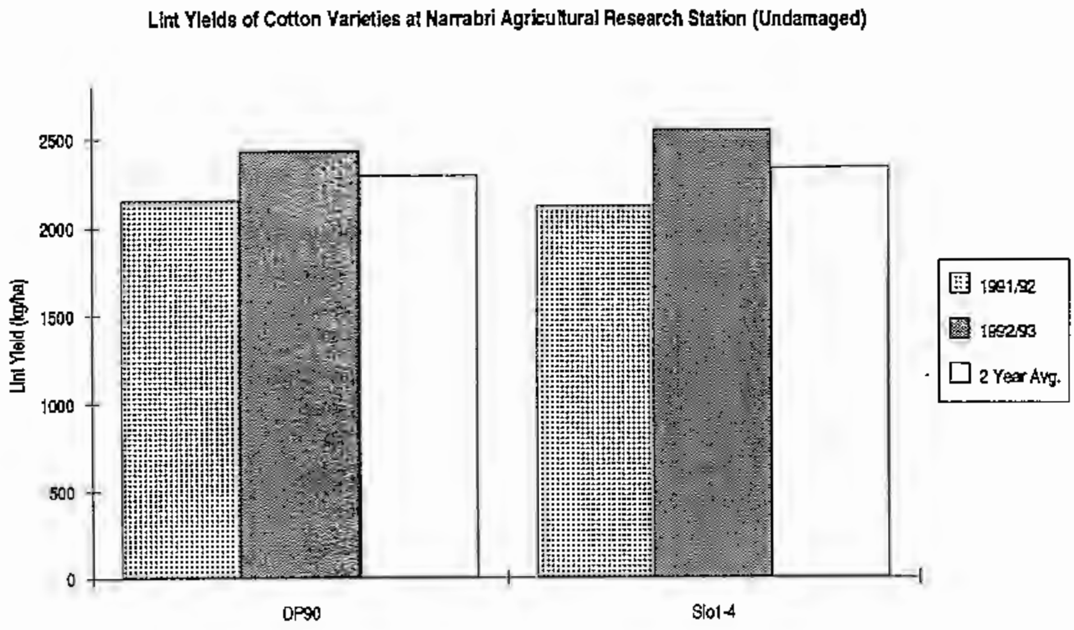
Looking only at undamaged cotton, we see that at Narrabri Agricultural Research Station, over two years of trials, Siokra 1-4 on average only yielded 44kg (0.2 bale) per hectare more than DP90. This would not be a significant difference in yield. ie. no real difference in yield potential is seen between the varieties at this site. Correspondingly, at Auscott Narrabri, Deltapine 90, Siokra 1-4 and Sicala 33 have similar yield potential with Siokra L22 showing a slight yield advantage (106 -123 kg/ha) on average in the seasons tested. At "Merinda West" looking at undamaged cotton , Deltapine 90 shows a slight advantage in yield potential (97 - 199kg) over Siokra L22 and Sicala. Siokra 1-4 on average yielded slightly lower than Siokra L22 and Sicala by 22 - 49kg/ha.

Lint Yield Table No.2

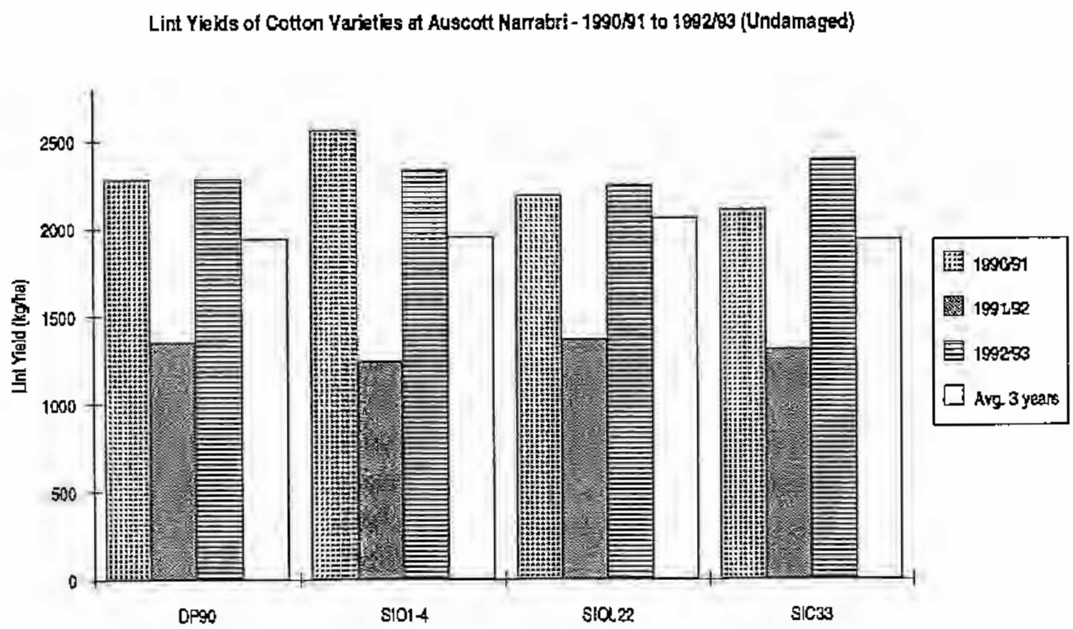
Average Lint Yields for Cotton Varieties at Hail Sites 1990/91 to 1992/93
(Undamaged Cotton)

		DP90		SIO1-4		SIOL22		SIC33	
		kg/ha	(ba/ha)	kg/ha	(ba/ha)	kg/ha	(ba/ha)	kg/ha	(ba/ha)
Auscott Narrabri	1990/91	2278	(10.13)	2557	(11.36)	2187	(9.72)	2100	(9.34)
	1991/92	1350	(6.00)	1238	(5.50)	1364	(6.06)	1306	(5.80)
	1992/93	2278	(10.13)	2331	(10.36)	2243	(9.97)	2391	(10.63)
	Avg.	1938	(8.62)	1949	(8.66)	2055	(9.13)	1932	(8.59)
Merinda West	1990/91	1552	(6.90)	1496	(6.65)	1459	(6.49)	1595	(7.09)
	1991/92	2128	(9.46)	1699	(7.55)	2039	(9.06)	1620	(7.20)
	1992/93	2339	(8.66)	2468	(9.14)	2229	(8.26)	2593	(9.61)
	Avg.	2006	(8.34)	1887	(7.78)	1909	(7.94)	1936	(7.96)
Narrabri Ag.	1991/92	2152	(9.57)	2118	(9.42)				
Research Station	1992/93	2430	(10.80)	2552	(11.34)				
	Avg.	2291	(10.18)	2335	(10.38)				

Lint Yield Graph No.2

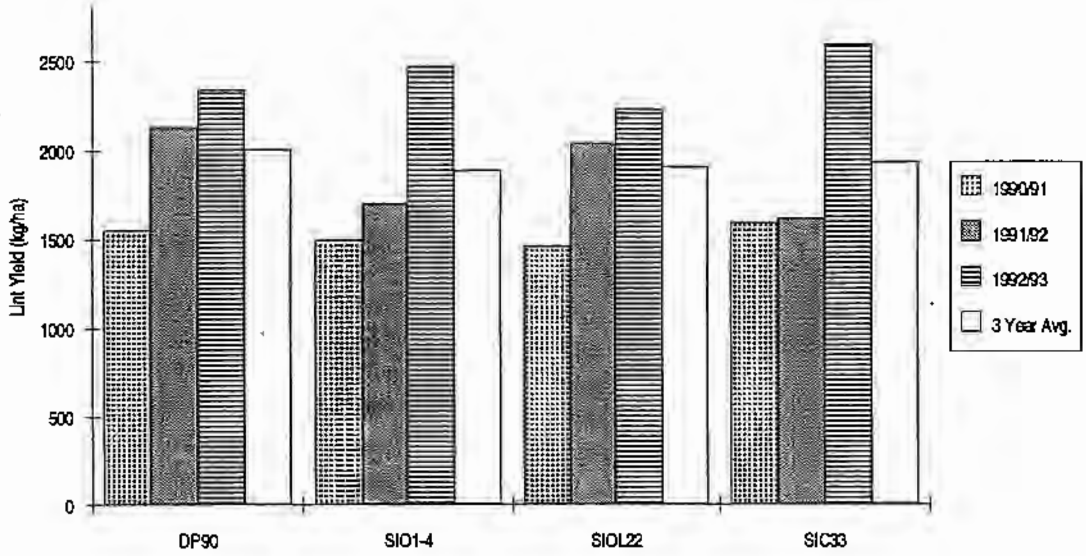


Lint Yield Graph No.3



Lint Yield Graph No.4

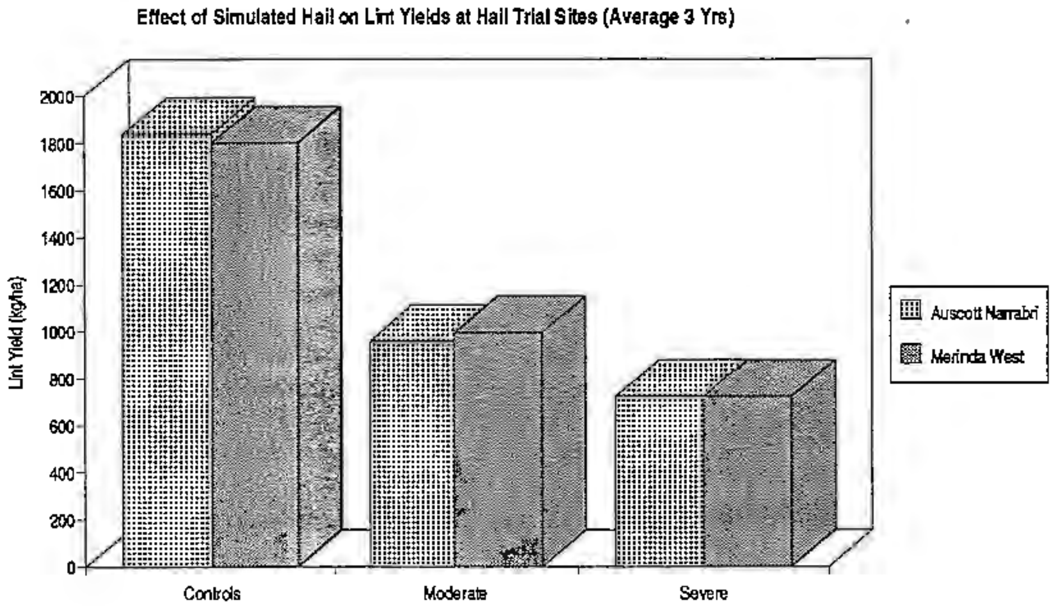
Lint Yields of Cotton Varieties at "Merinda West" - 1990/91 to 1992/93 (Undamaged)



Effect of Simulated Hail on Lint Yields

Simulated hail damage reduced lint yields significantly in all trials, as displayed in Graph No.5 and Table No.3. Increased severity of damage increased the loss consistently. Difficulties encountered in hail simulation as previously described, do not allow for separation of damage into levels and so further analysis of the effect of damage levels on lint yield in the large scale trials is not accurate for this data.

Lint Yield Graph No.5



Lint Yield Table No.3

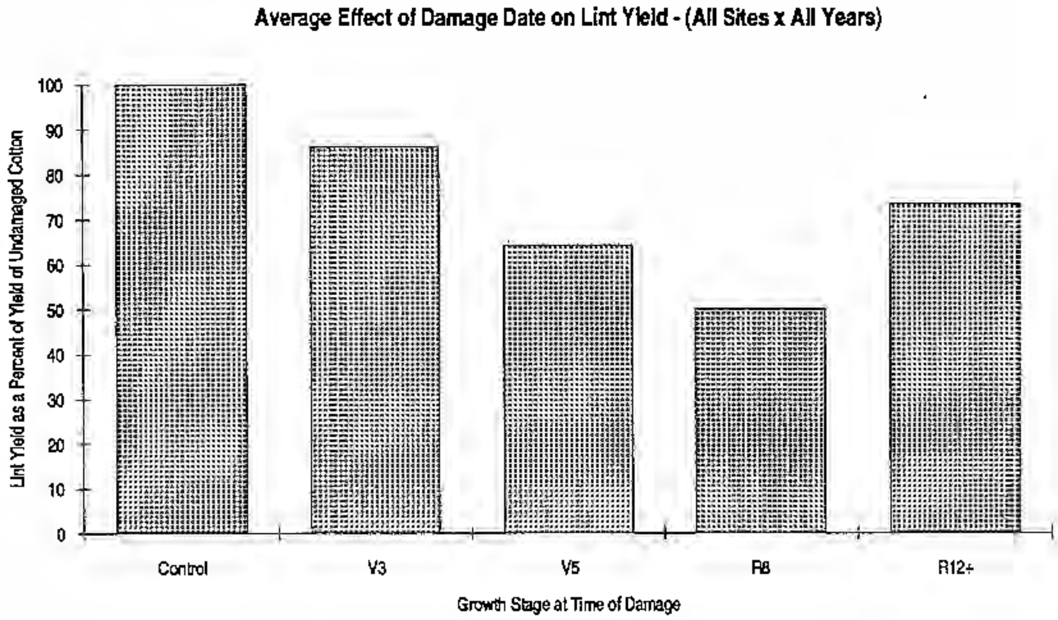
Effect of Simulated Hail Damage on Lint Yields

		Undamaged Lint Yield		Moderate Damage Lint Yield		Severe Damage Lint Yield	
		kg/ha	(ba/ha)	kg/ha	(ba/ha)	kg/ha	(ba/ha)
Auscott Narrabri	1990/91	2281	(10.14)	1334	(5.93)	1134	(5.04)
	1991/92	1310	(5.82)	541	(2.40)	367	(1.63)
	1992/93	1925	(8.56)	996	(4.43)	667	(2.96)
	Avg.	1838.67	(8.17)	957	(4.25)	722.67	(3.21)
Merinda West	1990/91	1525	(6.78)	718	(3.19)	577	(2.56)
	1991/92	1871	(8.32)	1280	(5.69)	924	(4.11)
	1992/93	2006	(8.92)	989	(4.40)	664	(2.95)
	Avg.	1800.67	(8.00)	995.67	(4.43)	721.67	(3.21)
N.A.R.S.	1991/92	2559	(11.37)	1707	(7.59)		
	1992/93	2412	(10.72)	1616	(7.18)		
	Avg.	2485.5	(11.05)	1661.5	(7.38)		

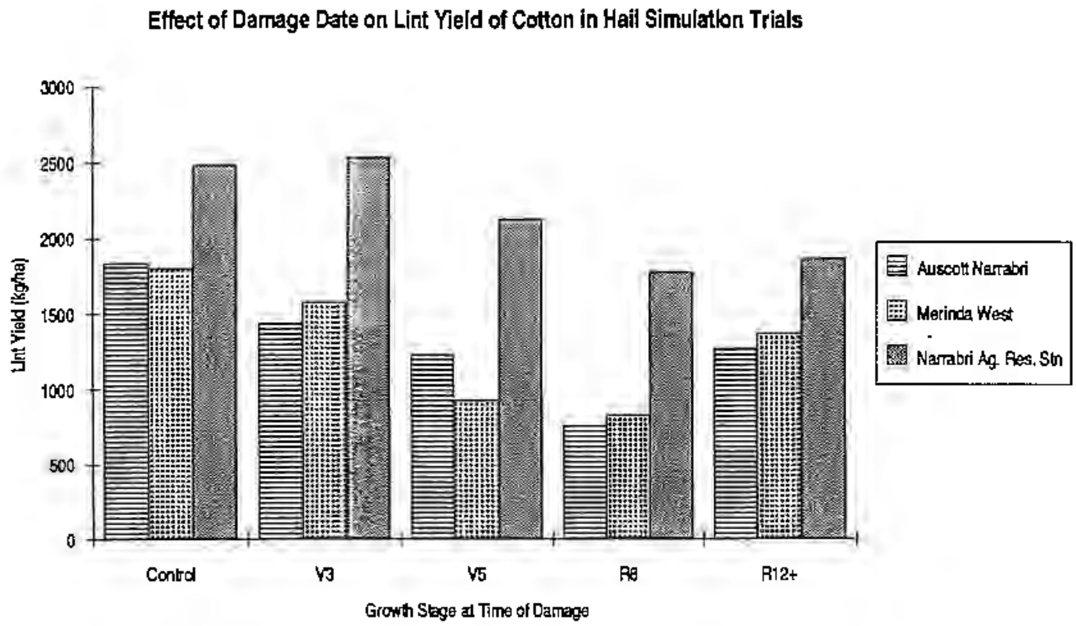
Effect of Damage Date on Lint Yield

The growth stage of the crop at the date of hail damage forms the basis of the crop loss assessment procedures. Results in these trials reinforce the fact that growth stage at the time of damage is the major factor contributing to yield loss. Graph Nos.6 & 7 clearly displays the effect of damage date on lint yield.

Lint Yield Graph No.6



Graph No.7



Damage in the early vegetative phase (V3) has produced an average yield depletion of 11.27%. But climatic conditions immediately following damage have a significant effect on the extent of any yield loss. Indeed, four of the eight trials showed lint yields either statistically equal to or greater than the undamaged cotton when damaged in the V3 stage, primarily due to warm conditions immediately following damage, (See Lint Yield Table No.4 and Climatic Data) allowing for rapid recovery and/or a longer than average season allowing the regrowth after damage at the V3 stage of growth to fully mature.

Late vegetative damage (V5) produced an average 32.7% yield depletion.

Mid-reproductive stage damage (R8) caused the greatest reduction in yield, averaging 47.8% in these trials. By this stage of development of a crop, the season is well advanced and there is little time left for any fruit produced on regrowth to mature and hence contribute to yield.

Late reproductive stage damage where the crop is either close to full maturity or fully mature sees a loss in yield directly correlated with the severity of damage as there is no time for regrowth to occur and the plant will only mature undamaged fruit already set.

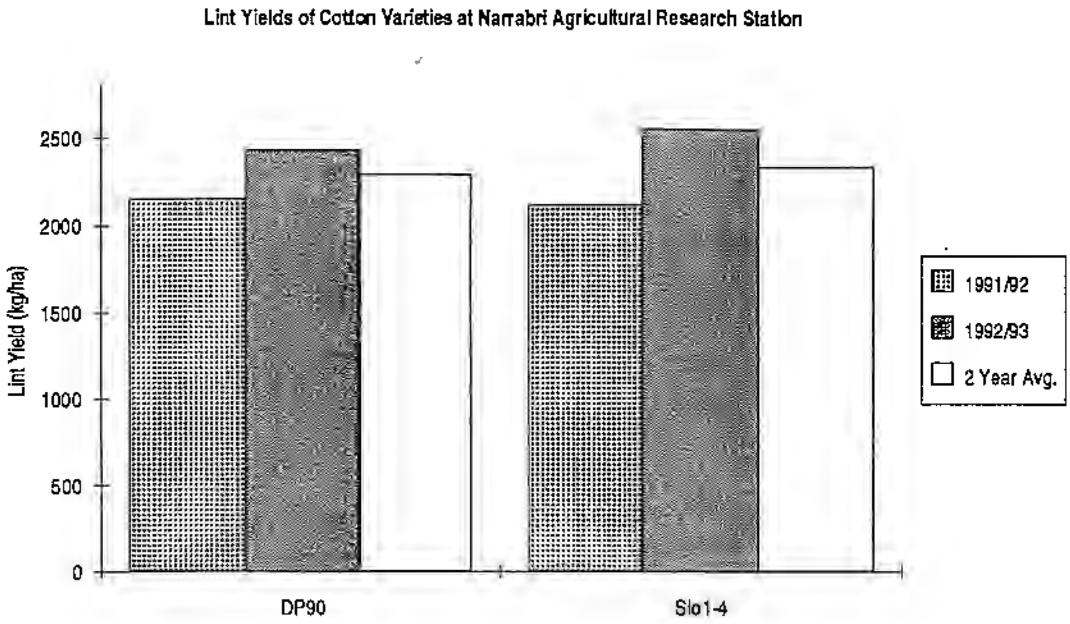
Lint Yield Table No.4

Lint Yields For Damage at Different Growth Stages in Simulated Hail Damage Trials

		Control	V3 Stage	V5 Stage	R8 Stage	R12+ Stage		
		kg/ha (ba/ha)	kg/ha (ba/ha)	kg/ha (ba/ha)	kg/ha (ba/ha)	kg/ha (ba/ha)		
Auscott Narrabri	1990/91	2281 (10.14	2348 (10.44)	1864 (8.28)	848 (3.77)	1270 (5.64)	***	l.s.d.=131.62kg
	1991/92	1310 (5.82)	766 (3.40)	590 (2.62)	543 (2.41)	1059 (4.71)	***	l.s.d.=104.64kg
	1992/93	1925 (8.56)	1202 (5.34)	1227 (5.45)	876 (3.89)	1479 (6.57)	***	l.s.d.=176.23kg
	Avg.	1838.7 (8.17)	1438.67 (6.39)	1227 (5.45)	755.67 (3.36)	1269.33 (5.64)		
Merinda West	1990/91	1525 (6.78)	1349 (6.00)	784 (3.48)	615 (2.73)	1013 (4.50	***	l.s.d.=85.38kg
	1991/92	1871 (8.32)	1917 (8.52)	913 (4.06)	910 (4.04)	1692 (7.52)	***	l.s.d.=218.21kg
	1992/93	2006 (8.916)	1453 (6.46)	1069 (4.75)	951 (4.23)	1405 (6.24)	***	l.s.d.=164.07kg
	Avg.	1800.7 (8)	1573 (6.99)	922 (4.10)	825.33 (3.67)	1370 (6.09)		
Narrabri	1991/92	2559 (11.37)	2573 (11.44)	1973 (8.77)	2099 (9.33)	1886 (8.38)	***	l.s.d.=30.09kg
Research Station	1992/93	2412 (10.72)	2490 (11.07)	2277 (10.12)	1449 (6.44)	1840 (8.18	***	l.s.d.=45.32kg
	Avg.	2485.5 (11.04)	2531.5 (11.25)	2125 (9.44)	1774 (7.88)	1863 (8.28)		
Overall Average (kg/ha)		1986.13	1762.25	1337.13	1036.38	1455.5		

Breaking down the date of damage into it's effect on the different varieties at each trial site shows no significant effects. For example, at the Narrabri Agricultural Research Station, if we plot the effect of damage date for each variety, we see a similar response in terms of lint yield for each variety. (Graph No. 8) Differences are not statistically significant. So we are not seeing a difference in final lint yields between the varieties after damage at any of the damage dates tested. This holds true for the two large scale trials.

Lint Yield Graph No.8



With improved hail simulation techniques, it may be possible to investigate the effect of different severities and types of hail damage on the regrowth of varieties after damage. The techniques devised for these trials as previously described do not allow for an accurate analysis of the effect of damage level on varietal regrowth.

Effect of Simulated Hail on Damage on Maturity of Cotton

In cotton production, yield loss is not the only factor of importance after hail damage. Date to full maturity is of critical importance in management decisions and hail damage can have a significant effect on the maturity of a crop. Delayed maturity may explain the yield difference sometimes observed between varieties after hail damage.

In these trials yield loss was investigated as was date to 60% open which is considered the date of full maturity for production purposes. We are hence able to look at the effect of simulated hail and the effect of damage at the four different growth stages tested on crop and varietal maturity.

At the Narrabri Agricultural Research Station where the crop was allowed to go through to full maturity with extra irrigations and sprays as required, a clear picture is seen. Maturity was delayed between 12.8 and 16.9 days by damage simulation (Level of Significance 0.001%) when looking at the overall effect of damage at moderate levels. As presented in Maturity Tables No. 1 & 2, simulated hail damage clearly delays the maturity of cotton. The large scale trials show delays of 1.95 - 6.75 days when averaged over all treatments. (Highly Significant - 0.001% Level)

Maturity Table No.1

Effect of Level of Simulated Hail Damage on Maturity
(Average of 2 Sites - Auscott Narrabri & Merinda West)

	DD to 60%	Days to 60%	Delay DD	Delay Days
1990/91				
Moderate Damage	2234.50	178.45	41.50	1.95
Severe Damage	2236.50	178.65	43.50	2.15
1991/92				
Moderate Damage	1955.50	168.35	60.50	5.30
Severe Damage	1931.00	166.00	36.00	2.95
1992/93				
Moderate Damage	1991.50	175.25	60.00	6.75
Severe Damage	1994.50	175.10	63.00	6.60
Average 3 Years				
Moderate Damage	2060.50	174.02	54.00	4.67
Severe Damage	2054.00	173.25	47.50	3.90

(DD = Day Degrees)

Maturity Table No.2

Delay in Maturity Due to Simulated Hail Damage at Narrabri Agricultural Research Station

	DD to 60%	Days to 60%	Delay DD	Delay Days
1991/92				
Control	1822.5	155.5	0	0
Moderate Damage	1959	168.3	136.5	12.8
1992/93				
Control	1807	160.6	0	0
Moderate Damage	1952.5	177.5	175.5	16.9
Average of 2 Years				
Control	1814.75	158.05	0	0
Moderate Damage	1955.75	172.9	156	14.85

(DD = Day Degrees)

Damage simulation date is again shown to be of major importance as vegetative stage damage is shown to produce a delay in maturity which can be highly significant in terms of commercial picking date especially when seasonal weather conditions/climatic areas are taken into account.

As presented in Maturity Table No.3 on a three year average, V5 stage damage delayed maturity by 10.56 days and V3 stage damage delayed maturity by 5.63 days. This is compared to reproductive stage damage where R8 stage damage only produced a delay of 2.25 days on average. Late reproductive stage damage where bolls are relatively mature and no regrowth occurs sees an advance in date to maturity (average 2.19 days)

In a season with good growing conditions after damage and good picking conditions these delays may not be of a commercial concern. But cotton is produced over a large area and over a range of climatic areas and such ideal conditions for regrowth after damage are not guaranteed. When stage of growth at time of damage is combined with variety or level of damage we seen a compounded effect.

Maturity Table No.3

Effect of Date of Simulated Hail Damage on Maturity
(Average of 3 Sites)

1990/91	Day Degrees to 60%	Days to 60%	Delay Day Degrees	Delay Days
V3 Stage Damage	2225.25	177.55	41.75	3.05
V5 Stage Damage	2304.50	185.65	116.50	11.15
R8 Stage Damage	2191.50	173.85	-1.00	-1.45
R12+ Stage Damage	2128.00	172.95	35.50	-1.55
1991/92				
V3 Stage Damage	1918.17	170.63	44.17	4.43
V5 Stage Damage	1970.00	162.30	96.00	9.20
R8 Stage Damage	1934.67	166.40	60.67	5.87
R12+ Stage Damage	1865.00	159.47	-26.67	-0.83
1992/93				
V3 Stage Damage	1985.00	175.27	96.00	9.40
V5 Stage Damage	2001.67	177.20	112.67	11.33
R8 Stage Damage	1910.67	168.20	21.67	2.33
R12+ Stage Damage	1845.50	161.67	-43.50	-4.20
3 Year Average				
V3 Stage Damage	2042.81	174.48	60.64	5.63
V5 Stage Damage	2092.06	175.05	108.39	10.56
R8 Stage Damage	2012.28	169.48	27.11	2.25
R12+ Stage Damage	1946.17	164.69	-11.56	-2.19

As presented in Maturity Table Nos.4-6, overall, the varieties were not delayed to any different degree by simulated hail damage. Although if this data is separated out into sites we find that under some conditions a variety can be more delayed than other by simulated hail. In five of the eight trials, varieties are shown to be delayed to different degrees when you compound the effect of simulated damage on a variety with damage at particular damage dates More significant results relate to the 1991/92 trials and hence imply a seasonal effect. The results are enhanced by the differing varietal susceptibility to disease, crop management decisions and seasonal conditions.

At the Narrabri Agricultural Research Station (1991/92) damage simulation at the V5 stage delayed maturity by 23 days which was highly significantly different (0.001%) from all other dates. V3 stage damage also produced a significantly different delay of 6 days. With no difference between R8 and R12+ stage damage and the controls. Looking at the two tested varieties separately, we find that there is an interaction between damage at stage R8 and variety as Siokra 1-4 is delayed in maturity by 3.2 days in comparison to Deltapine 90 damaged at the same date which actually shows an advance in maturity of 0.5 days.

Such a consistent and significant difference in maturity is not seen between these two varieties in the larger scale trials. What should be noted that in the unusually long season of 1990/91 no variety by damage date interaction is significant which reflects the fact that all varieties were able to go through to full maturity.

At Auscott Narrabri in 1991/92, we see a different result. , Siokra L22 is delayed in maturity compared to other varieties at the V5 and R12+ stages of damage. The advanced maturity of Siokra 1-4 damaged at the R8 and R12+ stages would be considered to be the effect of verticillium wilt infection as this variety was heavily infected by verticillium and damage at this stage would compound its effect which would see premature senescence. At "Merinda West", Siokra L22 also shows a delay in maturity when damaged at the R12+ stage in contrast to the earlier maturity of the other varieties after damage.

In 1992/93, under different seasonal conditions, we see no real differences in effect of damage date on varietal maturity at Narrabri Agricultural Research Station. At "Merinda West", Siokra L22 and Sicala 34 are delayed by damage at V3, V5 and R12+ stage compared to other varieties.

Maturity Table No.4

Effect of Damage Date on Maturity of Varieties at Narrabri Agricultural Research Station Hail Trials 1991/92 & 1992/93

		1991/92				1992/93				Average	
Growth Stage at Damage	Variety	Day Degrees to 60%	Days to 60%	Delay Day Degrees	Delay Days	Day Degrees to 60%	Days to 60%	Delay Day Degrees	Delay Days	Delay Day Degrees	Delay Days
V3	Deltapine 90	1935	166.5	70	7	1965	175.25	125	11.8	97.5	9.4
	Siokra 1-4	1842	157.5	72.5	6.5	1915	170.6	133	12.1	102.75	9.3
V5	Deltapine 90	2100	181.5	237	22	1984	177.7	144	14.2	190.5	18.1
	Siokra 1-4	2045	176.5	275	25.5	1948	173.5	166	15	220.5	20.25
R8	Deltapine 90	1855	159	-7.5	-0.5	1875	166.8	35	3.3	13.75	1.4
	Siokra 1-4	1811	154.2	41	3.2	1867	166	85	7.5	63	5.35
R12+	Deltapine 90	1845	158	-17.5	-1.5	1760	156.75	-80	-6.7	-48.75	-4.1
	Siokra 1-4	1785	152.3	15	1.3	1763	156.8	-22	-1.7	-3.5	-0.2

Maturity Table No.5

Effect of Hail Damage Date on Maturity of Varieties in Auscott Narrabri Hail Trials 1990/91 - 1992/93

		1990/91				1991/92				1992/93				Avg.	
Growth Stage at Damage	Variety	DD to 60%	Days to 60%	Delay DD	Delay Days	DD to 60%	Days to 60%	Delay DD	Delay Days	DD to 60%	Days to 60%	Delay DD	Delay Days	Delay DD	Delay Days
V3	Deltapine 90	2230	184.2	52	5	2000	172.1	84	7	1954	175.6	68	8.1	68.00	6.70
	Siokra 1-4	2180	181.4	-8	1	2000	173.2	81	7	1875	176.4	56	15.1	43.00	7.70
	Siokra L22	2230.5	186.25	-2	1	2001.5	173.3	58	7	1908	169.5	-42	-4.1	4.67	1.30
	Sicala 33/34	2217	183.1	22	2	2006	173.8	76	8	1863	165.4	41	3.8	46.33	4.60
V5	Deltapine 90	2323	193.7	117	12	2009	173.7	98	10	1975	176.4	53	5.6	89.33	9.20
	Siokra 1-4	2285	189.75	87	9	2010	174.2	99	10	1960	174.7	94	9.4	93.33	9.47
	Siokra L22	2302	191.5	72	7	2012	174.35	40	4	1924	170.9	-15	-3.6	32.33	2.47
	Sicala 33/34	2297	191	114	11	2008.5	174	87	9	1820	165.4	44	0	81.67	6.67
R8	Deltapine 90	2285.5	189.75	41	4	1957	169.6	9	2	1971	175	112	10	54.00	5.33
	Siokra 1-4	2227	184	109	10	1908	163.8	-10	-1	1981	177.1	151	14.8	83.33	7.93
	Siokra L22	2245.5	185.7	15	2	1987	171.9	41	4	1910	169.6	-37	-3.8	6.33	0.73
	Sicala 33/34	2218	183.25	32	3	1958	168.8	32	3	1915	170.1	75	6.9	46.33	4.30
R12+	Deltapine 90	2186	180.25	-10	-1	1917	163.8	-2	-1	1952	175	60	7	16.00	1.67
	Siokra 1-4	2148	176.4	-17	-2	1908	163.8	-6	0	1935	171.9	55	4.9	10.67	0.97
	Siokra L22	2168	178.4	-53	-5	1934	166.4	2	0	1936	172	-29	-3.3	-26.67	-2.77
	Sicala 33/34	2138	175.5	-55	-5	1912.5	164.3	-31	-3	1815	161	-30	-2.8	-38.67	-3.60

(NB: "DD" = Day Degrees)

Maturity Table No.6

Effect of Hail Damage Date on Maturity of Varieties in "Merinda West" Hail Trials 1990/91 - 1992/93

		1990/91				1991/92				1992/93				Avg.	
Growth Stage at Damage	Variety	DD to 60%	Days to 60%	Delay DD	Delay Days	DD to 60%	Days to 60%	Delay DD	Delay Days	DD to 60%	Days to 60%	Delay DD	Delay Days	Delay DD	Delay Days
V3	Deltapine 90	2230	171.8	65	6.4					2046	177.5	-4	4.8	30.5	5.6
	Siokra 1-4	2232	171.2	12	2.4					2048	177.7	91	0.2	51.5	1.3
	Siokra L22	2240	173	20	2.2					2035	176.2	75	8.5	47.5	5.35
	Sicala 33/34	2184	167.3	46	4.5					2015	173.7	28	8.2	37	6.35
V5	Deltapine 90	2312	181.3	97	11					2050	178	52	6	74.5	8.5
	Siokra 1-4	2307	179.9	131	13.4	1866	159.6	15	1.5	2073	180.7	112	2.7	86	5.87
	Siokra L22	2294	178.4	80	8.1					2094	183.4	108	12.8	94	10.45
	Sicala 33/34	2312	180.3	170	17.1	1942	166.7	76	9.4	2057	178.6	93	10.4	113	12.3
R8	Deltapine 90	2145	163.5	-63	6.2	2015		115		1963	167.5	-27	-3.7	8.33	0.83
	Siokra 1-4	2111	160.5	-81	7.5	2016	173.6	171	16.4	1956	168.1	4	1.4	31.33	8.43
	Siokra L22	2122	161.4	-95	8.9	2034	175.4	159	14.8	1974	170.5	13	2.5	25.67	8.73
	Sicala 33/34	2130	162.2	-35	3.2	2019	174	176	16.7	1927	164.3	-6	-0.7	45	6.4
R12+	Deltapine 90	2102	159.5	-51	-4.5	1868	173.5	-57	-8.3	1933	160.5	-49	-9.6	-52.33	-7.47
	Siokra 1-4	2098	159.4	-59	-6.1	1836	156	-1	-0.8	1895	164.6	-75	-4.4	-45	-3.77
	Siokra L22	2097	159.3	-123	-11.3	1868	159.9	3	0.4	1944	166	-8	-0.9	-42.67	-3.93
	Sicala 33/34	2047	159.7	-93	-3.3	1820	154.9	-15	-1.6	1927	164.3	-18	-2	-42	-2.3

(NB: "DD" = Day Degrees)

The performance of Siokra L22 in these trials is related to its characteristic later maturity under normal conditions. The ranking of varieties in this trials in respect to days to maturity are presented in Maturity Table No. 7.

At Auscott Narrabri in 1992/93, in total contrast, Siokra L22 is more advanced in maturity compared to other varieties at all damage dates. This does not relate to any weather condition changes which in any case would affect other varieties of similar growth characteristics. Diseases such as verticillium wilt did not affect the trial to any great degree and we would expect to see other varieties so affected. No differences in the number of unopen bolls at picking were found to indicate that defoliation practices affected the variety and so advanced maturity of Siokra L22 in this trial remains unexplained.

Most of the differences in maturity between varieties which have been presented represent only differences of 5-6 days between the earliest and latest varieties and the commercial significance of the results will depend on the area where the crop is grown. The results show a difference in effect over the three seasons over which the trails were carried out and so we can surmise that similar results can be expected if the three seasons of data were instead to represent three different climatic areas. This theory is currently being tested in actual historic case studies by the industry loss adjnsters with the aim that by overlaying a factor relating the expected average growth conditions post damage (time available to regrow / average heat units remaining) in a particular area to the assessed loss, assessment may then more closely relate to actual loss for a given prodnction area. Data from theses trials will provide the base data for comparison of the accuracy of any assessment calculations incorporating a "seasonal length" factor.

Maturity Table No.7

Date to 60% Open For Varieties at Hail Trial Sites - Undamaged

	1990/91		1991/92		1992/93		Average	
	Day Degrees to 60%	Days to 60%	Day Degrees to 60%	Days to 60%	Day Degrees to 60%	Days to 60%	Day Degrees to 60%	Days to 60%
N. A. R.S.								
Deltapine 90			1865	159.5	1840	163.5	1853	162
Siokra 1-4			1770	151	1782	158.5	1776	155
Auscott Narrabri								
Deltapine 90	2225	182	1923	165	1887	168	2012	171
Siokra 1-4	2175	179	1918	165	1848	164	1980	169
Siokra L22	2228	184	1948	168	1953	174	2043	175
Sicala 33/34	2189	180	1930	166	1846	164	1988	170
Merinda West								
Deltapine 90	2190	168	1900	168	1887	170	1992	169
Siokra 1-4	2185	167	1851	158	1960	168	1999	165
Siokra L22	2218	171	1875	161	1965	168	2019	167
Sicala 33/34	2145	164	1850	158	1945	166	1980	163

Lint Quality and Hail Damage

A factor that is not normally looked at when investigating hail damage in cotton is lint quality. Hail damage affects lint yield and maturity, hence, we would expect to see quality problems in cotton affected by hail.

A summary of the lint quality characteristics of undamaged cotton from hail trials carried out from 1990/91 to 1992/93 is presented in Lint Quality Table No.1. The data represents what would be the "normal" quality characteristics of the varieties tested.

Lint Quality Table No.1

Average Quality Data - Hail Trials 1990/91 to 1992/93 - Undamaged Cotton

	Overall Average		Deltapine 90	Siokra 1-4	Siokra L22	Sicala 33/34
Auscott Narrabri	Length	(inches)	1.133	1.175	1.184	1.186
	Strength	(gram/tex)	29.666	28.482	29.698	29.793
	Micronaire		3.936	3.783	3.768	3.887
Merinda West	Length	(inches)	1.137	1.163	1.187	1.181
	Strength	(gram/tex)	30.077	28.636	30.018	30.455
	Micronaire		4.248	4.077	3.921	4.140
Narrabri Ag. Research Station	Length	(inches)	1.152	1.152		
	Strength	(gram/tex)	27.863	27.084		
	Micronaire		4.566	4.356		

These figures compare well with the historical averages for the same quality characteristics for each variety, displayed in Table No.2

Lint Quality Table No.2

Historical Averages in Lint Quality For Varieties.

Overall Average		Deltapine 90	Siokra 1-4	Siokra L22	Sicala 33	Sicala 34
Length	(inches)	1.15	1.18	1.20	1.20	1.18
Strength	(gram/tex)	28.50	26.60	27.80	28.10	29.90
Micronaire		4.20	3.90	3.90	4.00	4.10

(Source: Variety Trial Handbook - Cotton Seed Distributors Ltd 1993)

From this data we can see that Sicala has an inherently long and strong fibre with good micronaire. Deltapine 90 would be ranked second in respect to strength and micronaire but is not as longer fibre as Sicala or indeed Siokra 1-4 and Siokra L22. Both Siokras have a slightly lower micronaire but under normal conditions, the average micronaire is commercially not a problem.

Effect of Hail Damage on Lint Quality

If we now look at quality data for the hail trials carried out from 1990/01 to 1992/93 we can see the effect of hail damage on lint quality.

In Lint Quality Table No.3 we see that the overall effect of hail damage is to slightly increase fibre length. This was significant in four of the eight trials at 5% and 0.1% levels (See Appendix E). This difference in fibre length is not of commercial significance since all treatments have produced fibre length averages within the acceptable and marketable range.

Fibre strength, in general was not affected, with non significant variations in fibre strength measured at six of eight sites. Only in 1992/93 at Merinda West at severe damage levels and at the Research Station was strength decreased significantly by hail damage simulation. During fibre development, the fibre first lengthens to it's final length and then cellulose is laid down to strengthen the fibre and so in cutting down the time available for fibre maturation, it would be expected that fibre strength would be reduced. This is not shown in these results. But it should be noted that the low micronaire of hail damaged samples indicates finer fibres present and in the actual measurement of fibre strength more fibres would be used in the test sample and the combined strength of the hail damaged sample may artificially high.

Importantly, micronaire was significantly decreased (0.001% Level of Significance) in seven of the eight trials. At Narrabri Agricultural Research Station in 1992/93, micronaire was reduced by damage but not to a statistical significant level.

Lint Quality Table No.3

Average Effect of Damage On Lint Quality
(Average 3 Sites x Years)

		Undamaged	Moderate Damage	Severe Damage
Length	(Inches)	1.169	1.172	1.173
Strength	(Grams/tex)	29.195	29.293	29.277
Micronaire		4.099	3.859	3.698

(** For Further details see Appendix E - Table Nos. 3A and 3B)

Summarising the effect of damage date on lint quality in Lint Quality Table 4, we see that each quality characteristic is affected differently depending on the growth stage at the time of damage.

Overall, fibre length is increased slightly by hail damage at each date except at the R8 stage. This relates to the fact that in the trials with damage at this stage we saw little recovery in terms of new bolls set etc. The plant's energy was put into maturing the bolls remaining after the hail damage since squares which were initiated did not set bolls due to climatic restrictions. Hence, in respect to fibre length, we are picking mature lint.

Overall, fibre strength is not marked affected by date of hail damage. Although when the data is subdivided into year and site (See Table 4A in Appendix E) we see that five of the eight trials show a significant change in fibre strength. At the Narrabri Agricultural Research Station, where both varieties and all treatment dates were able to go through to full maturity, no significant differences were found between dates of damage in respect to fibre strength.

Changes in micronaire with date of damage simulation were significant in six of the eight trials. Micronaire was reduced by damage in the vegetative stages and in the late reproductive stage damage (R12+) But was not reduced compared to undamaged cotton by damage at the R8 stage. In the R8 stage treatment we are removing all late bolls and any regrowth does not mature so the average micronaire for the sample is higher as it represents cotton from mature bolls. It should be noted that damage at the V5 stage reduces micronaire most significantly. This is primarily due to the fact that damage at this stage causes the longest delay in maturity and we are attempting to mature fibres at lower temperatures etc. and a larger proportion of bolls picked would be of lower micronaire. Micronaire average values presented are still within the commercially acceptable range of 3.5 - 4.9.

Lint Quality Table No.4:

Effect of Date on Lint Quality For Hail Trials
(Average of 3 Years x 3 Sites)

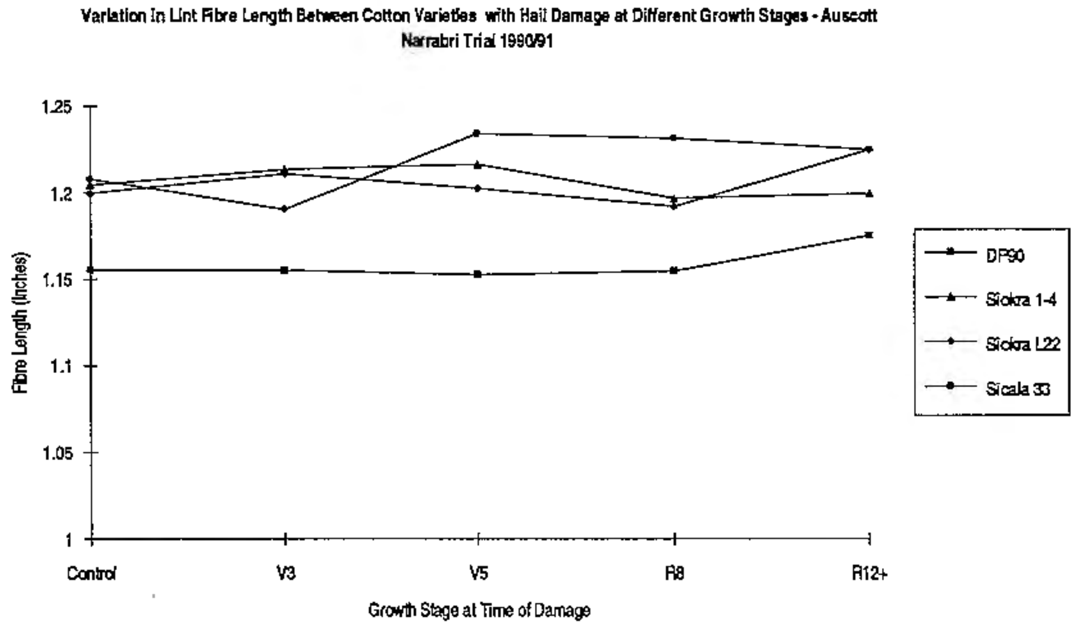
Growth Stage at Damage		Control	V3	V5	R8	R12+
Length	(Inches)	1.169	1.176	1.171	1.165	1.171
Strength	(Grams/tex)	29.195	29.599	29.151	29.106	28.895
Micronaire		4.099	3.978	3.660	4.126	3.997

(** For Further Details See Appendix E - Lint Quality Table Nos. 4A and 4B)

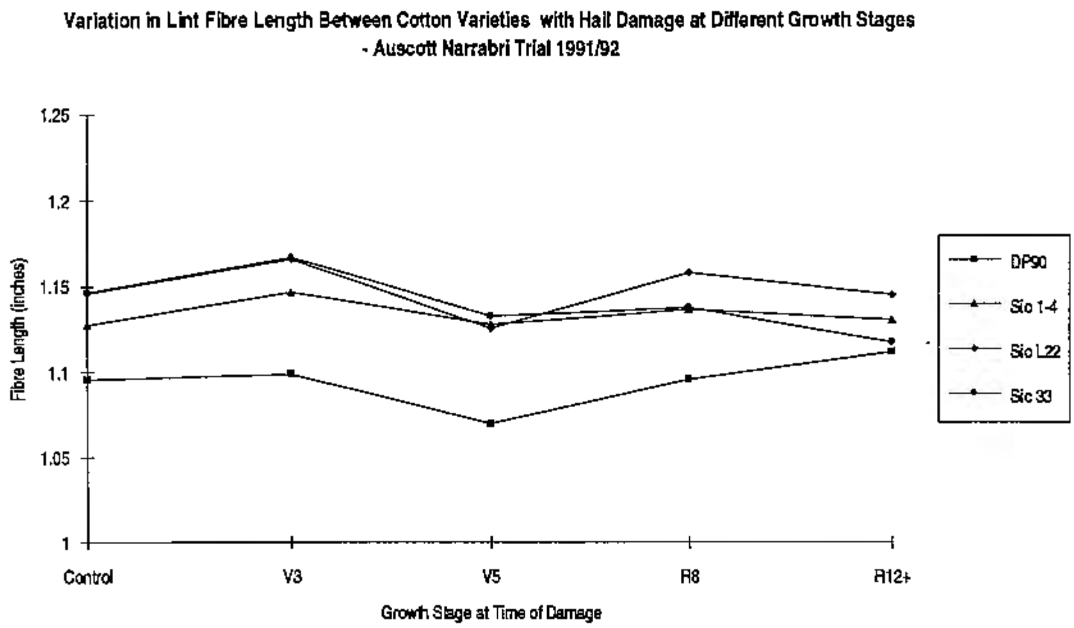
If now look at the performance of the different varieties, in quality characteristic terms, after damage by hail. We see that in 1991/92, varieties did react differently to hail. The result was not consistent across years nor site. But are presented to show that under some climatic conditions one variety may show more stable quality than another after hail damage.

In respect to fibre length, at Auscott Narrabri in both 1990/91, DP90 displayed a stable fibre length over all damage dates and consistently shorter than other varieties as expected by the historical data. Siokra 1-4 and Siokra L22 performed similarly after damage at V3, V5 and R8 stages of growth. But after damage at R12+, Siokra L22 showed a significantly increased fibre length over Siokra 1-4 and DP90. Sicala 33 showed some variability after vegetative stage damage but was consistent in fibre length after later damage and showed it's inherent lower fibre length after damage at these later dates. In 19991/92, Siokra L22 was more variable in fibre length than other varieties, showing larger changes in fibre length such as the significantly larger drop in fibre length after damage at the V5 stage (See Lint Quality Graph Nos.1& 2)

Lint Quality Graph No.1

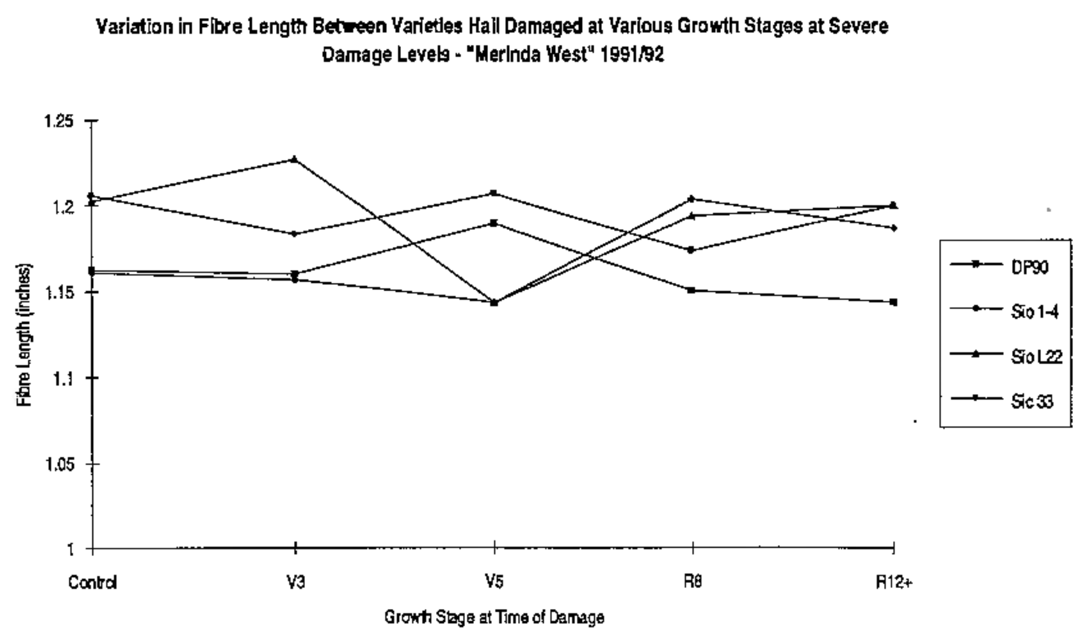


Lint Quality Graph No.2

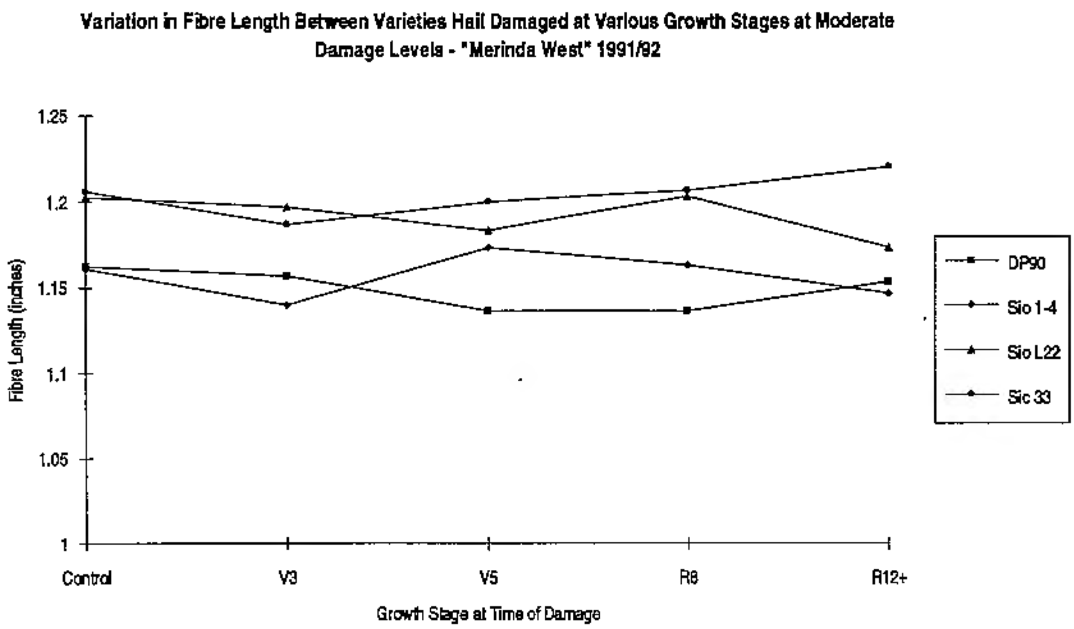


At "Merinda West" in 1991/92, we see a further difference in response of fibre length depending on the severity of hail damage. At severe damage levels, Siokra L22 displays the same significant drop in fibre length after damage in the V5 stage (See Graph No.3) as seen at Auscott Narrabri, but the same effect is not seen at moderate damage levels (See Graph No.4).

Lint Quality Graph No.3

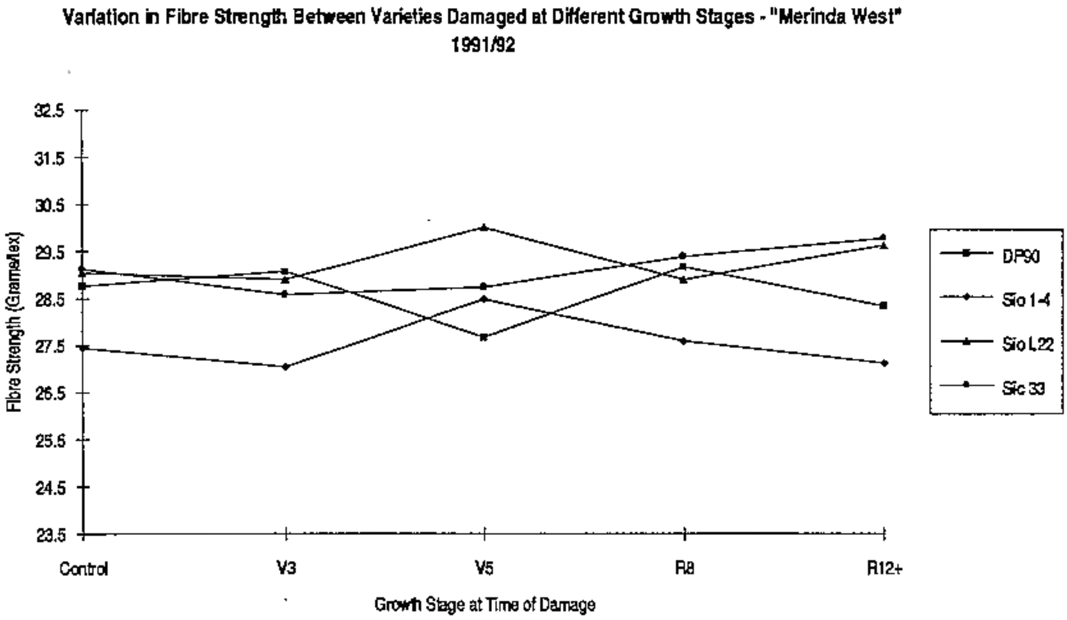


Lint Quality Graph No.4



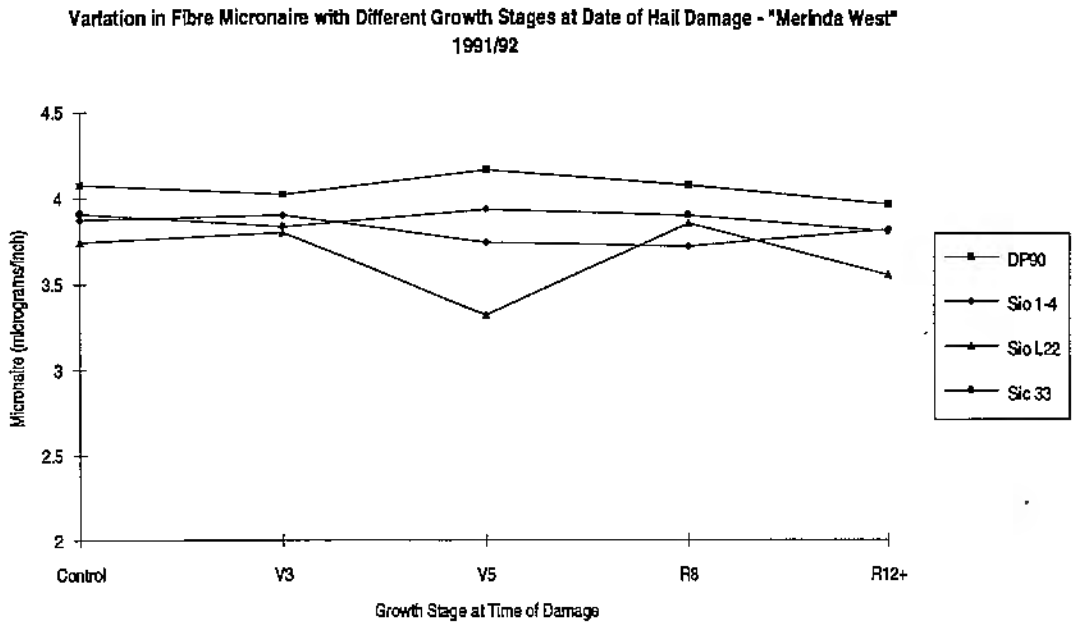
At "Merinda West" in 1991/92, we also see an interaction between variety and date of damage. The variability in strength for a particular variety across a series of damage dates is not significantly large. But when we look at the differences between varieties we see that DP90 shows an unusual drop in strength after V5 damage where Siokra 1-4 shows a significant increase in strength(See Graph No.5).

Lint Quality Graph No.5

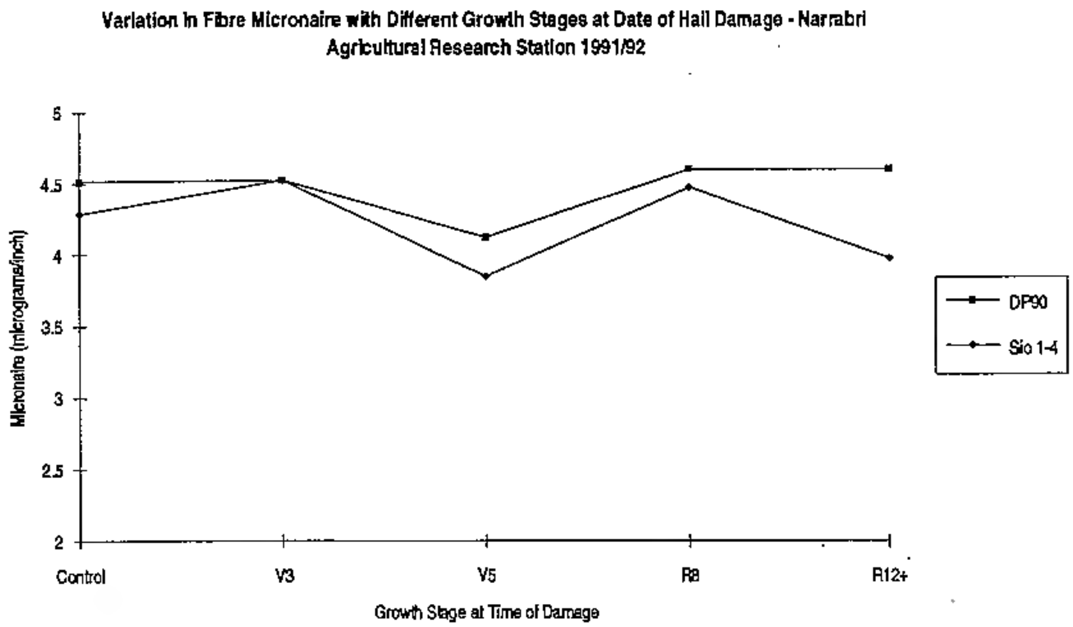


Siokra L22 also shows more variability than other varieties in micronaire readings after hail damage at "Merinda West" in 1991/92. In Graph No.6, Siokra L22 shows a significant drop in micronaire after V5 stage damage. This would relate to the longer season requirement of Siokra L22 and the larger proportion of immature fibres that would be present in the sample compounded by delay caused by V5 stage damage. Siokra 1-4 is shown to have a less stable micronaire than DP90 at the Narrabri Agricultural Research Station in 1991/92. Siokra 1-4 after R12+ damage shows a more significant drop in micronaire than DP90(See Graph No.7)

Lint Quality Graph No.6



Lint Quality Graph No.7



Fruit Development

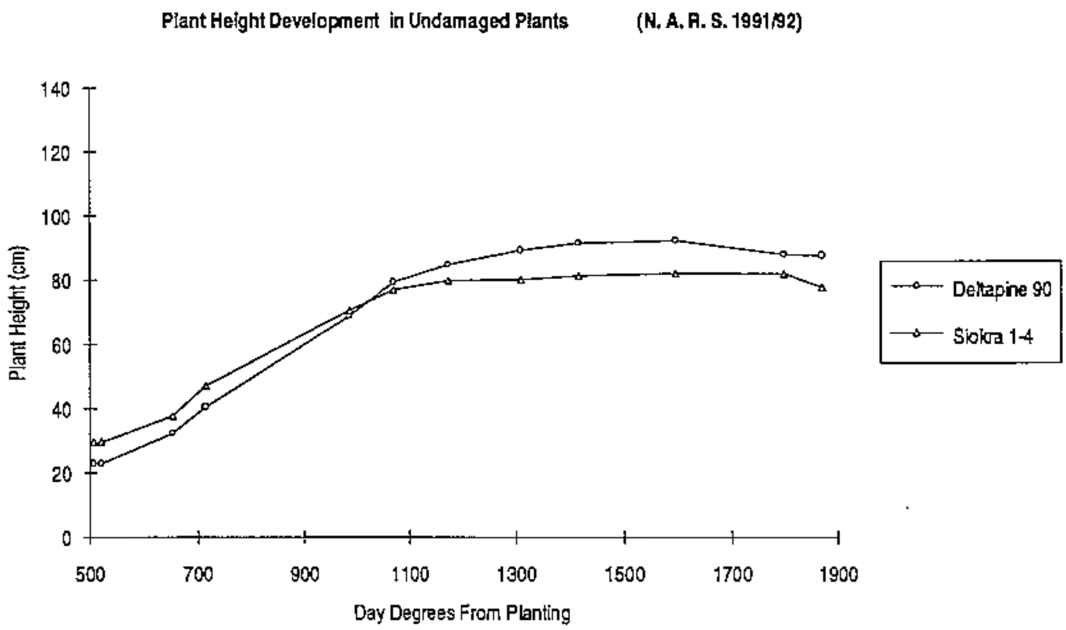
The lint yield data presented does not explain the differences in regrowth which can be observed at times in the field after a hail strike. It is obvious from the data collected in these trials that any such observations of differences in plant regrowth are not being translated through to yield differences at the end of season.

The small scale trials carried out at the Narrabri Agricultural Research Station enabled the fruiting patterns of Deltapine 90 and Siokra 1-4 to be looked at more closely. It should be noted that in the 1991/92 trial with very good growing conditions experienced following the vegetative stage damage simulations, observations of regrowth gave the impression that Siokra 1-4 was recovering at a more rapid rate. No such observations inferring differential regrowth were made in later stage simulations nor in the 1992/93 trial.

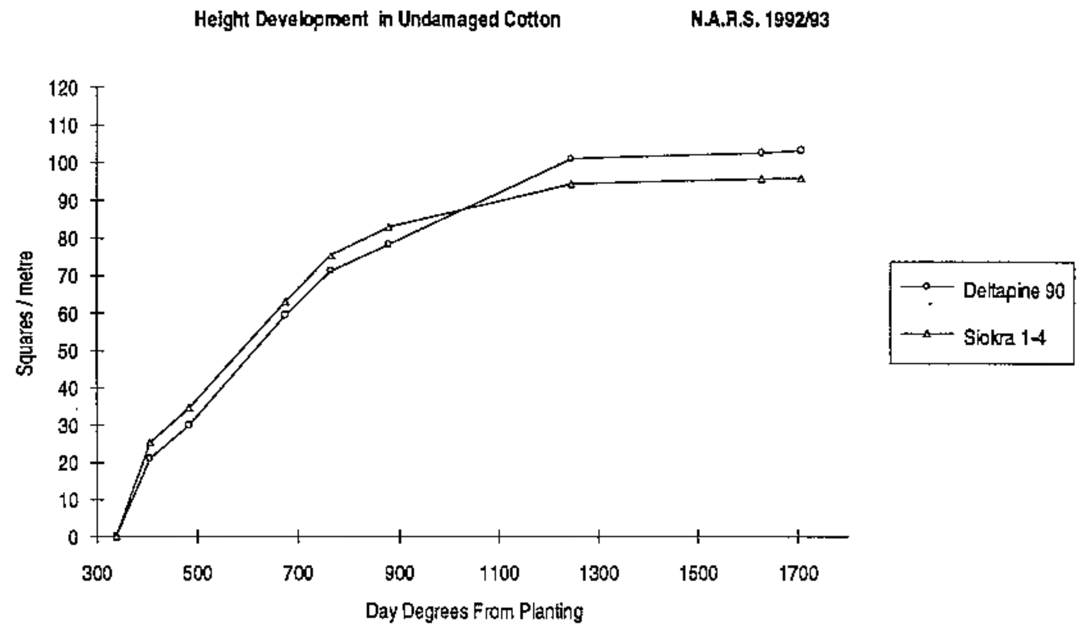
Presenting the fruit development and plant growth data graphically we can develop a picture of regrowth after hail.

If we take plant height to represent vegetative development and look at the increase in plant height over time of Deltapine 90 and Siokra 1-4 at the Narrabri Agricultural Research Station, Siokra 1-4 shows more rapid early growth than Deltapine 90 under normal or "undamaged" conditions. This is evident in both seasons as presented in Graph Nos.1 & 2. Siokra 1-4 reaches its maximum height earlier as it moves into its peak reproductive phase. Deltapine 90 continues in the vegetative phase longer and reaches a greater maximum height.

Graph No.1



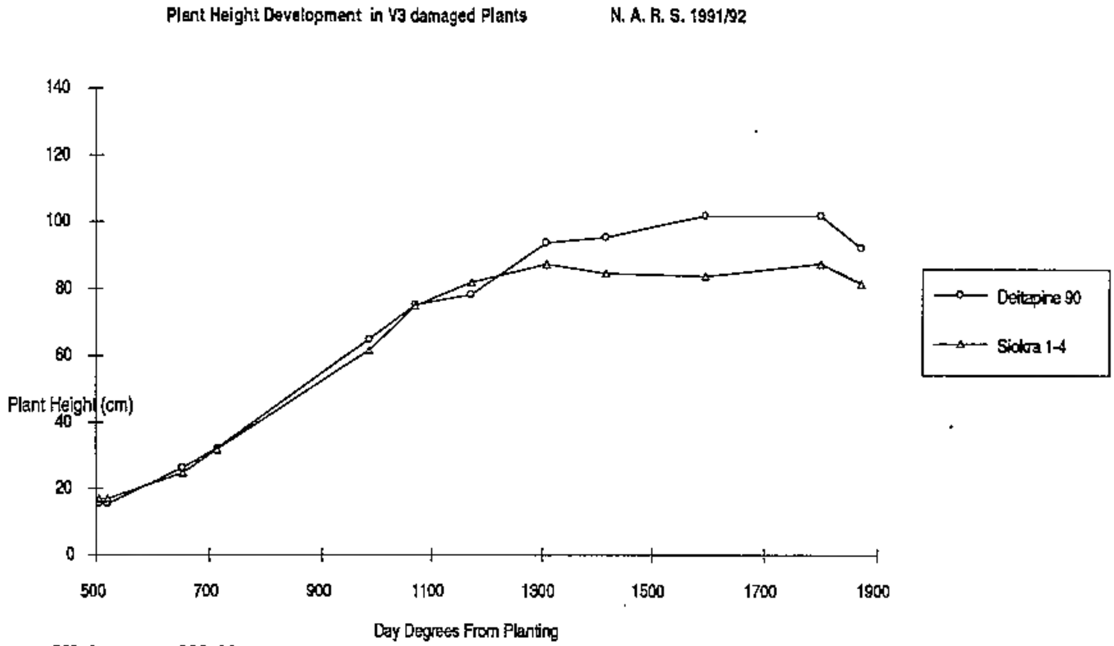
Graph No.2



After simulated damage at any of the four development stages which were tested, regrowth of varieties follows the same pattern as in undamaged cotton. (See Graph Nos.3-6) ie. Siokra 1-4 after damage shows a more rapid initial increase in plant height. Looking at the graphs provided, the differences in plant height displayed are significantly different for both trials and at most sampling dates. Of course, as the rate of height increase is declining in Siokra 1-4 as it approaches it maximum height, the Deltapine 90 growth rate does reach a point where it is not statistically different from that of Siokra 1-4. Once past this point, differences again become important.

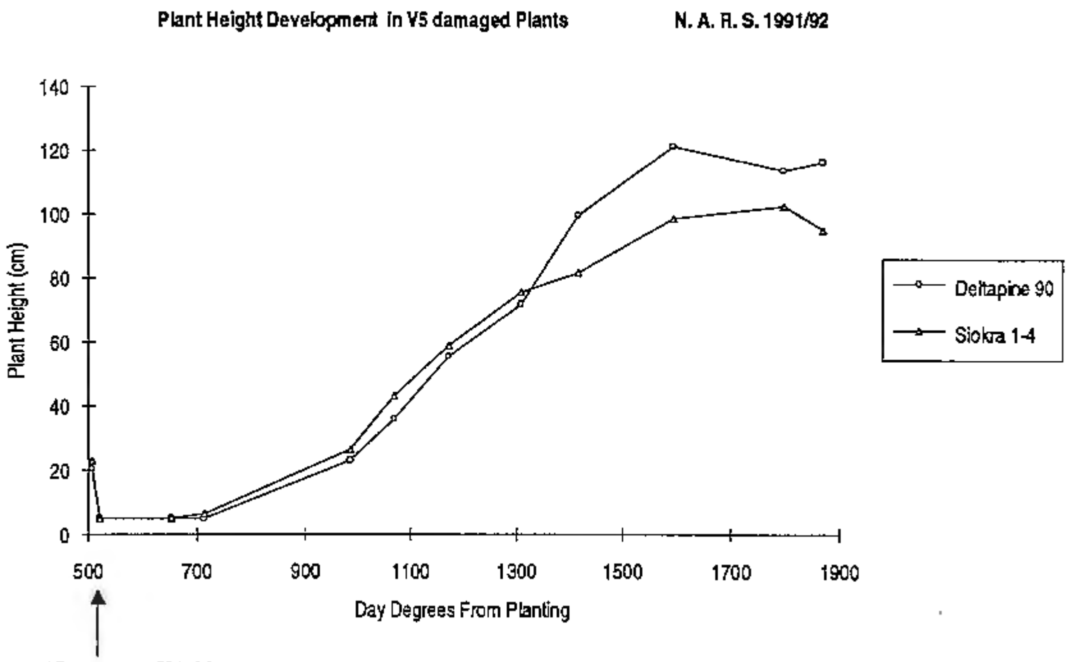
Climatic effects come into play where weather following hail damage is unusually detrimental to and advantageous to regrowth. For example in 1992/93, weather conditions after damage in that year were cool and growth of all cotton was less vigorous than in the previous year for a period of 4 - 6 weeks and the regrowth after vegetative damage was not as clearly defined between varieties. Likewise a period of cloudy weather at 1200 day degrees after planting in the 1991/92 trial and lasting for approximately one week affected increase in plant height and as displayed in later graphs it also affected square development. This weather corresponded to what should have been the period of rapid regrowth of vegetative material for plants damaged at the R8 stage and varietal differences in growth as displayed in Graph No.5 are less defined as in regrowth after damage at other growth stages.

Graph No.3



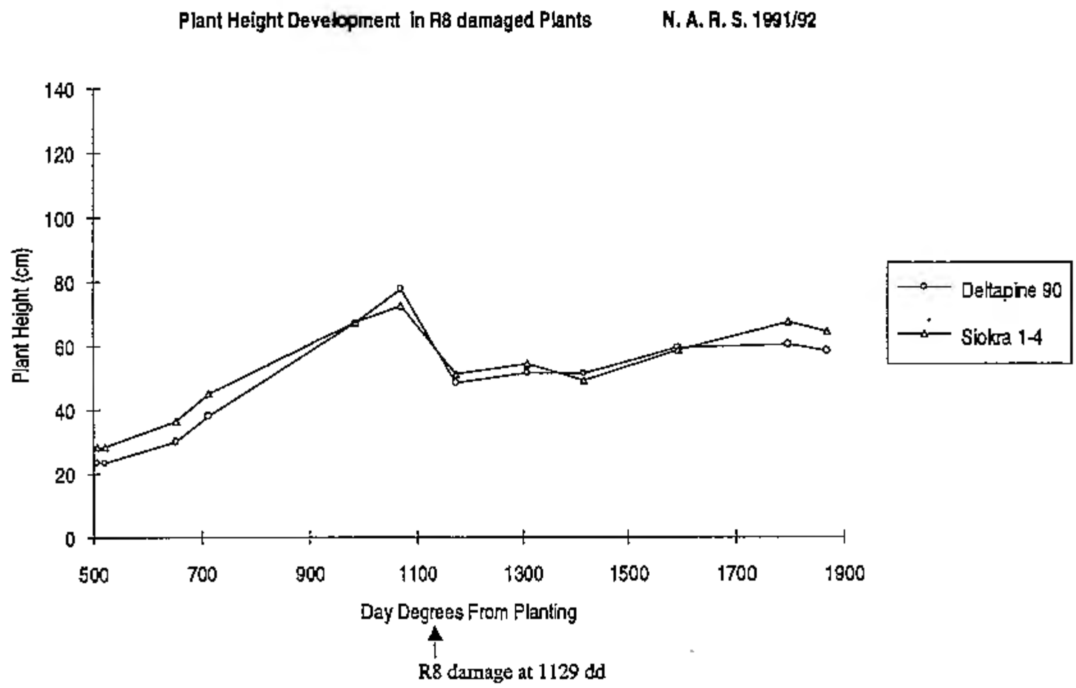
V3 damage at 203 dd

Graph No.4

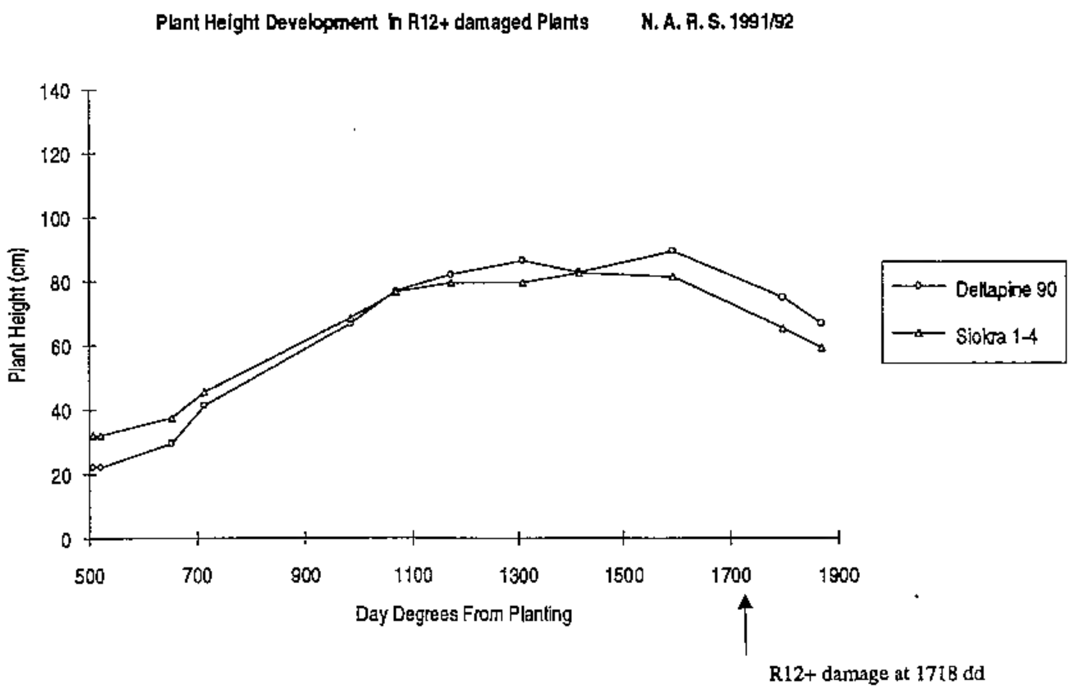


V5 Damage at 521 dd

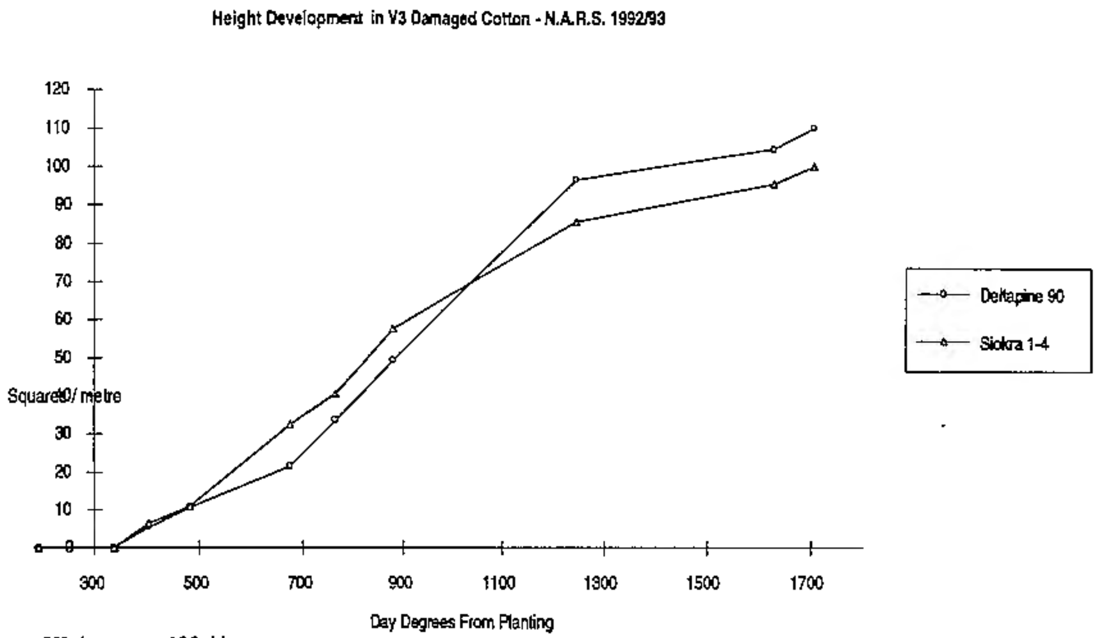
Graph No.5



Graph No.6

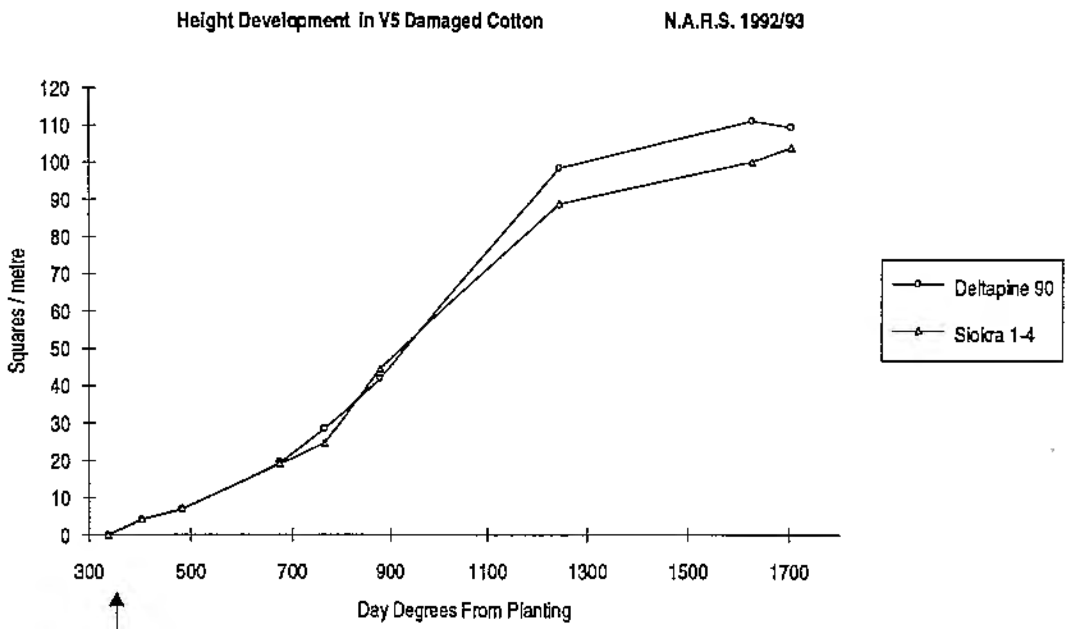


Graph No.7



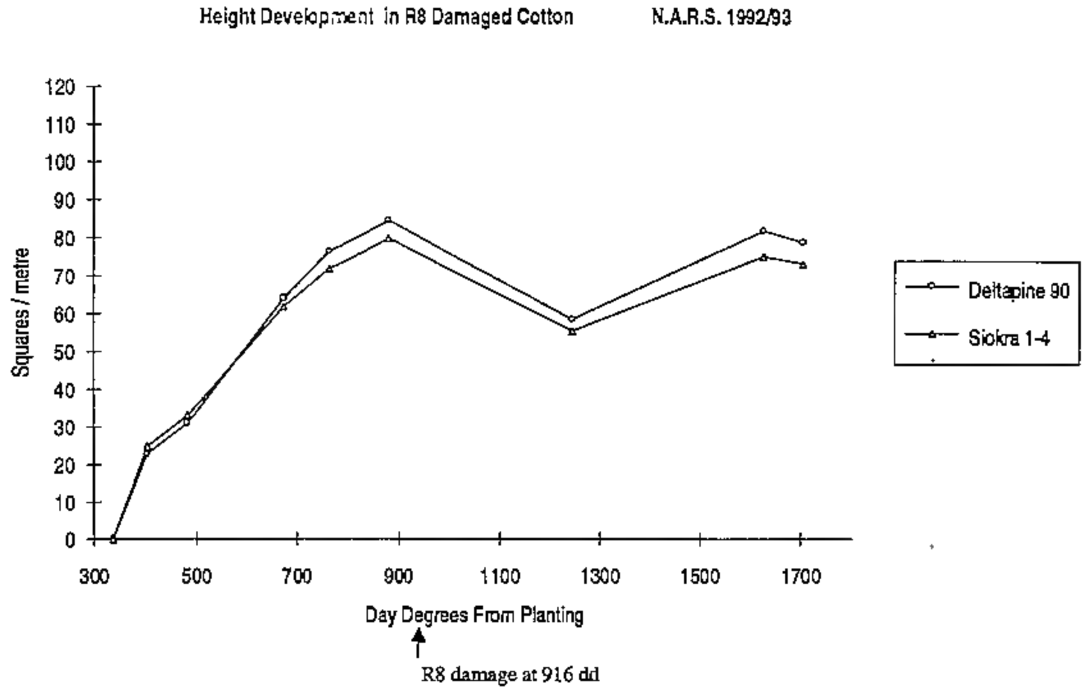
V3 damage at 190 dd

Graph No.8

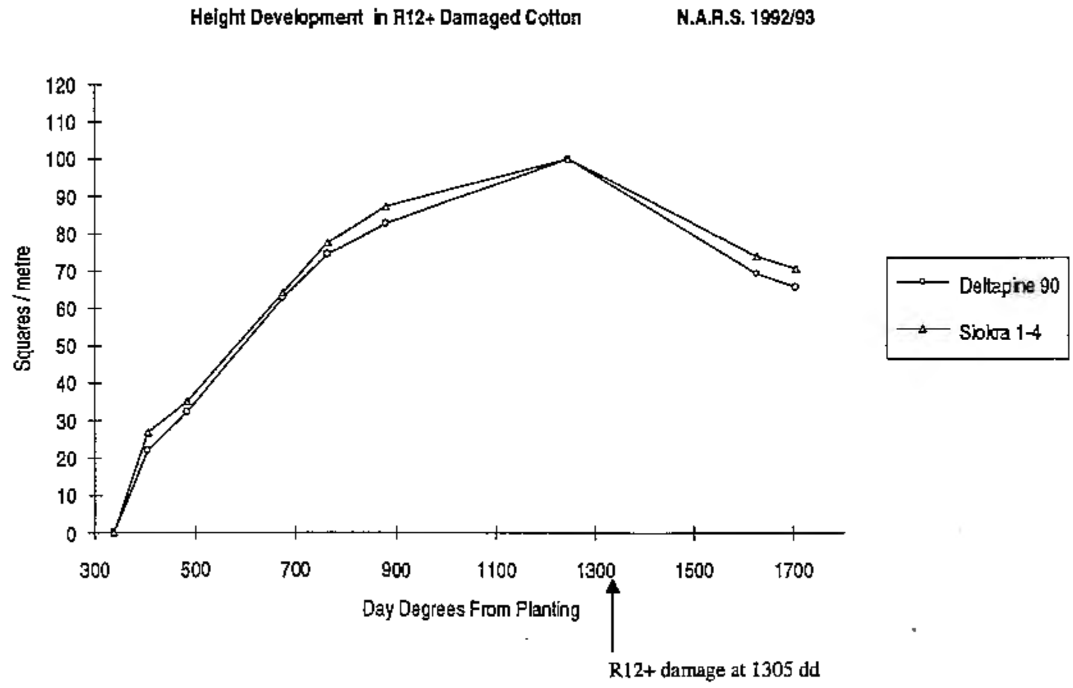


V5 damage at 337 dd

Graph No.9



Graph No.10



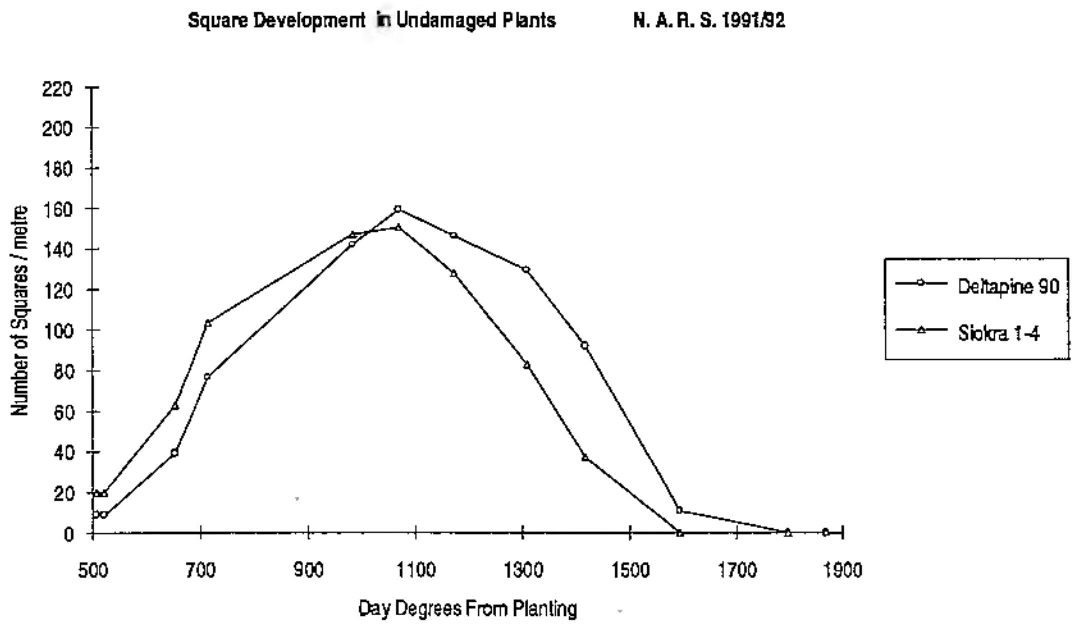
Square production in undamaged cotton follows a similar pattern to vegetative material production.

In 1991/92, varietal differences are statistically significant (0.001 % Level) in the period of early squaring. As the plants move into peak squaring differences become less statistically significant. Siokra 1-4 produces squares more rapidly and in greater numbers than Deltapine 90 and reaches it maximum number of squares at a time 100 - 150 day degrees prior to Deltapine 90. Differences in square numbers are not statistically different after peak squaring. In 1992/93 differences in square production are only statistically different at 500 day degrees after planting.

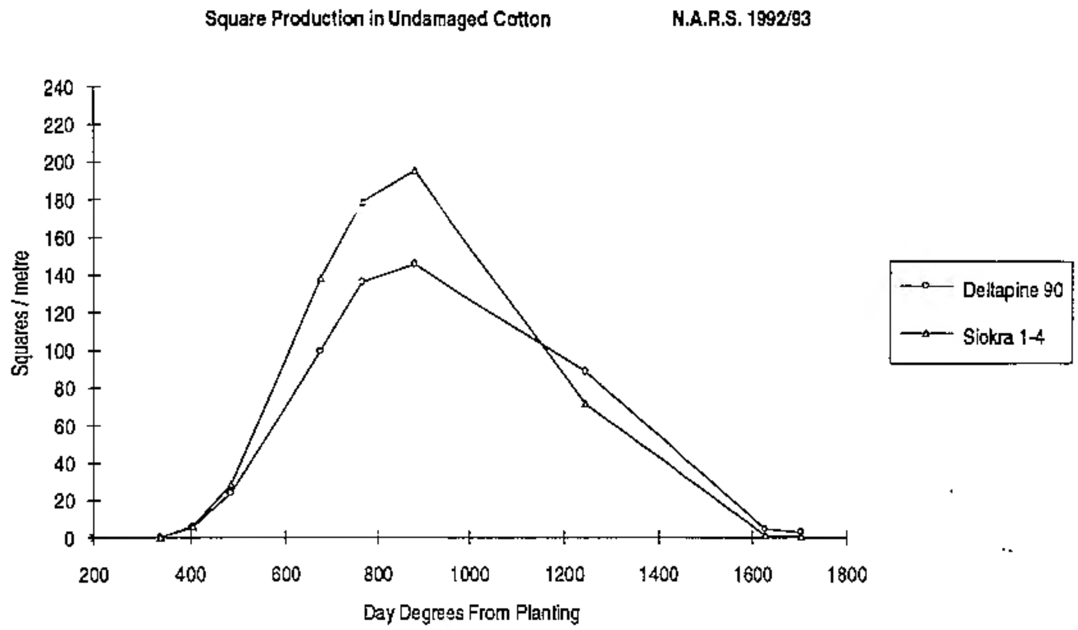
According to varietal records, Siokra 1-4 produces a large number of squares and more rapidly than Deltapine 90 but also sets fewer of these squares as bolls. So that at a site such as the Narrabri Agricultural Research where the two varieties have very similar yield potential, final boll numbers are very similar with boll setting percentages taken into account.

This is reflected in the hail trial data from the Narrabri Agricultural Research Station. Both in the undamaged and after damage at each of the growth stages tested as shown in Graph Nos.11 & 12.

Graph No.11



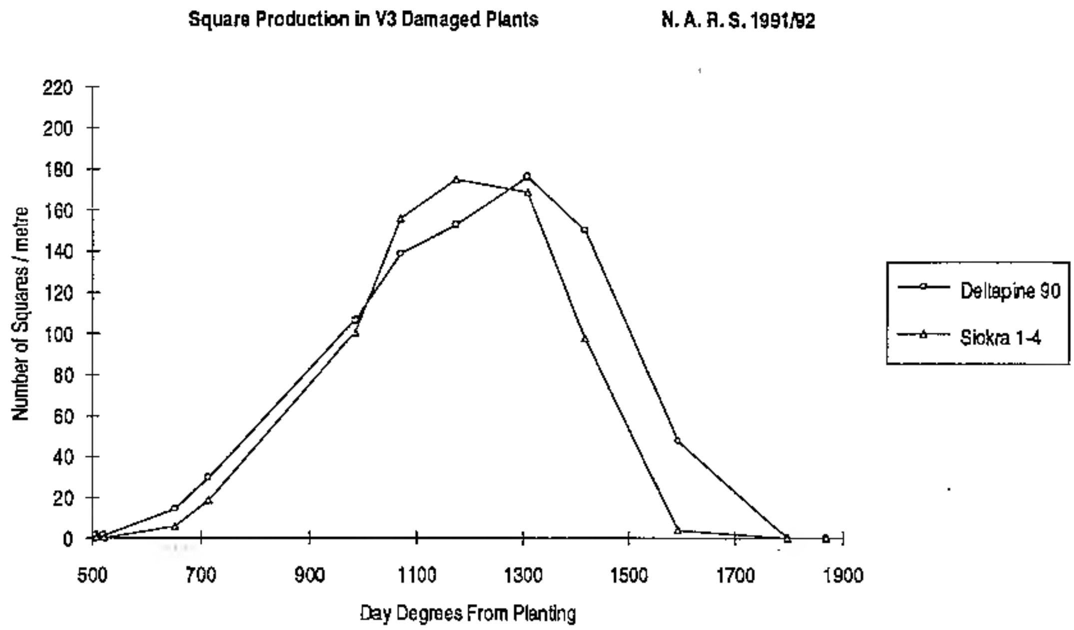
Graph No. 12



In 1991/92 , square production differences were significant at 653 dd and 714 dd for V3 and V5 damage; 1308 dd, 1416 dd and 1594dd for R8 damage. But not in final counts. Boll numbers were significant at dates delayed by 1-2 sampling dates and so represent the squares set as bolls and again boll numbers are not significantly different in the final counts. Significantly higher square numbers produced by a variety after represent an extra spurt of growth by that variety compared to the other variety and this would be observed by the grower as faster or more vigorous regrowth after hail in that variety. But as shown this is not translated to an increase in yield in terms of retained bolls. (See Graph Nos.13 - 16)

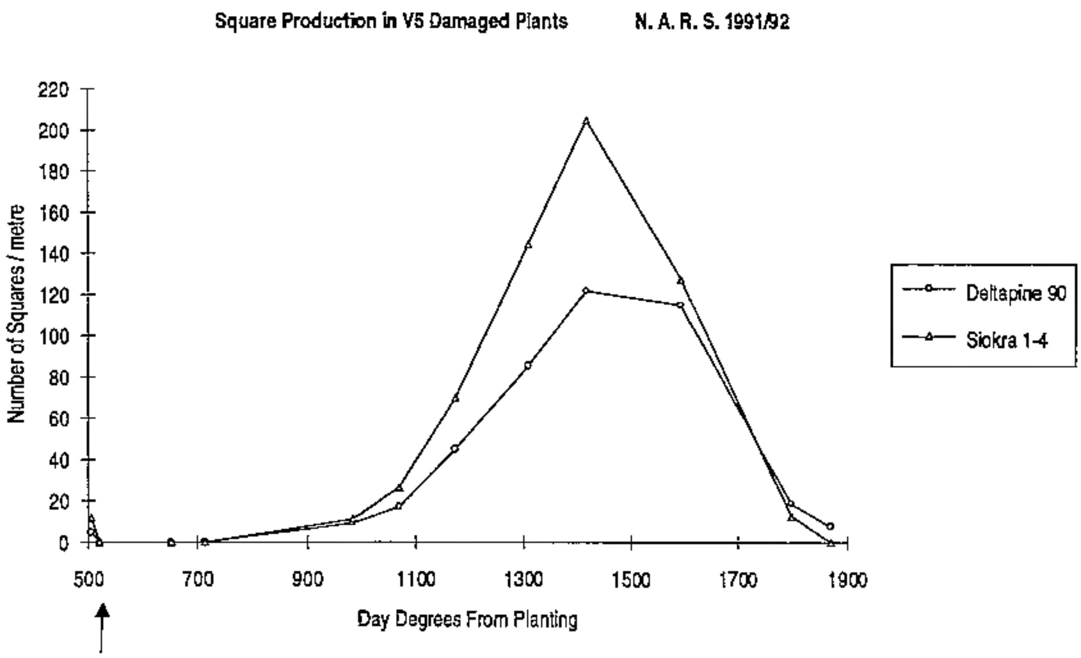
In 1992/93, cool weather conditions after damage in the vegetative stages did not allow the rapid regrowth experienced in 1991/92. Hence, the increased square uumbers for Siokra 1-4 were only significant at the 657 dd sampling date. Significant differences were not measured in later sampling dates for squares or bolls. (See Graph Nos. 17 - 20)

Graph No.13



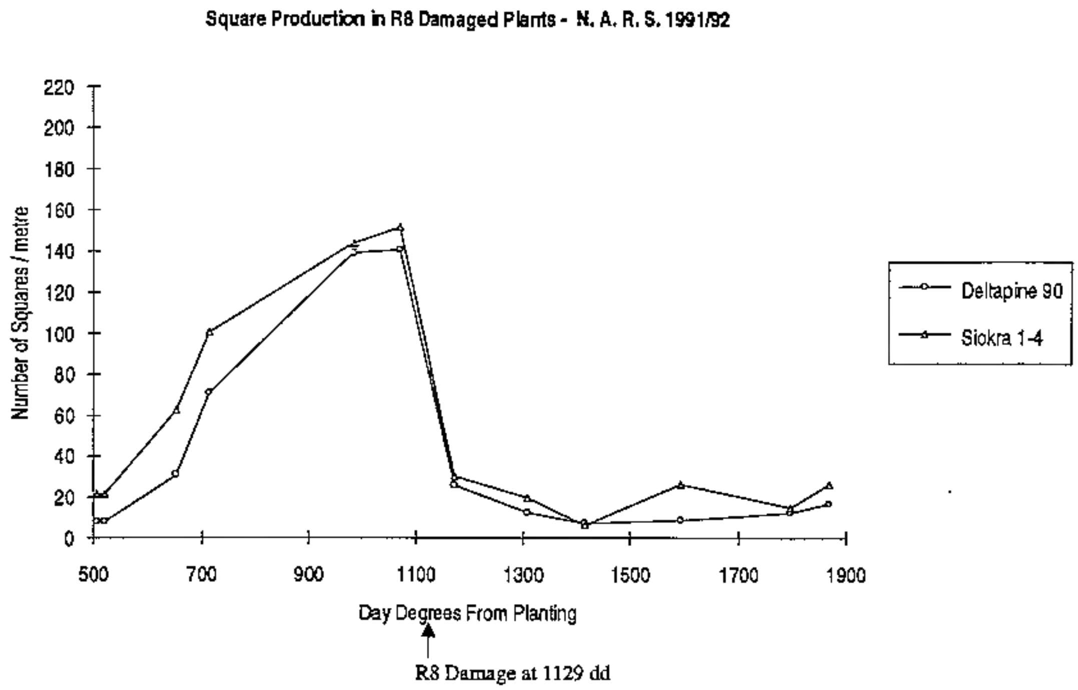
V3 damage at 203 dd

Graph No.14

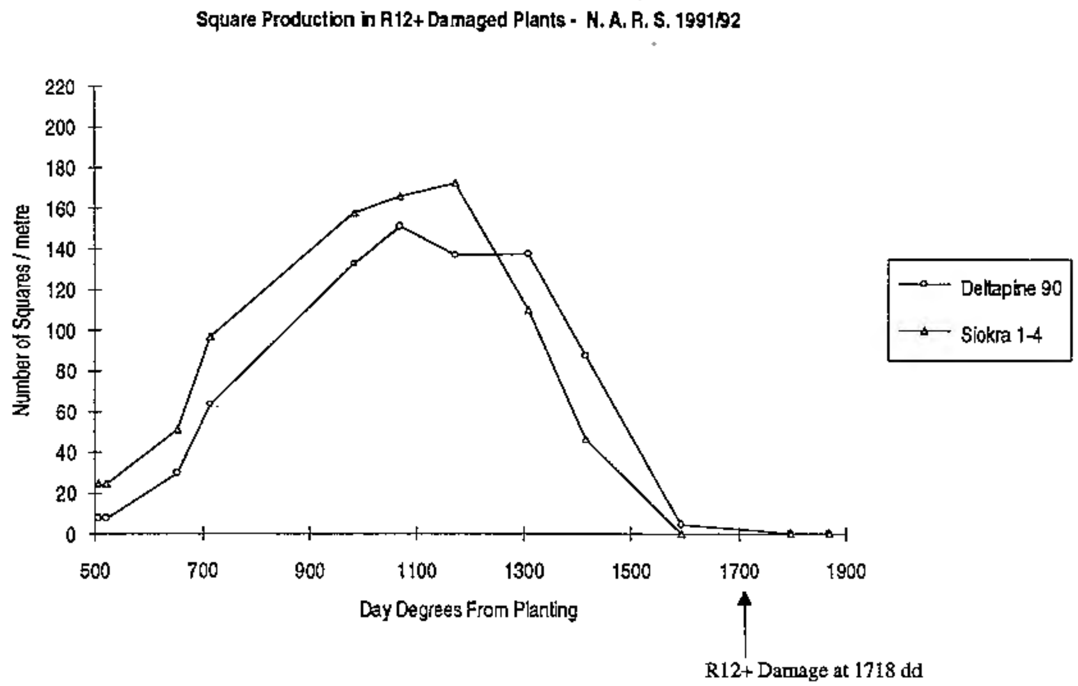


V5 Damage at 521 dd

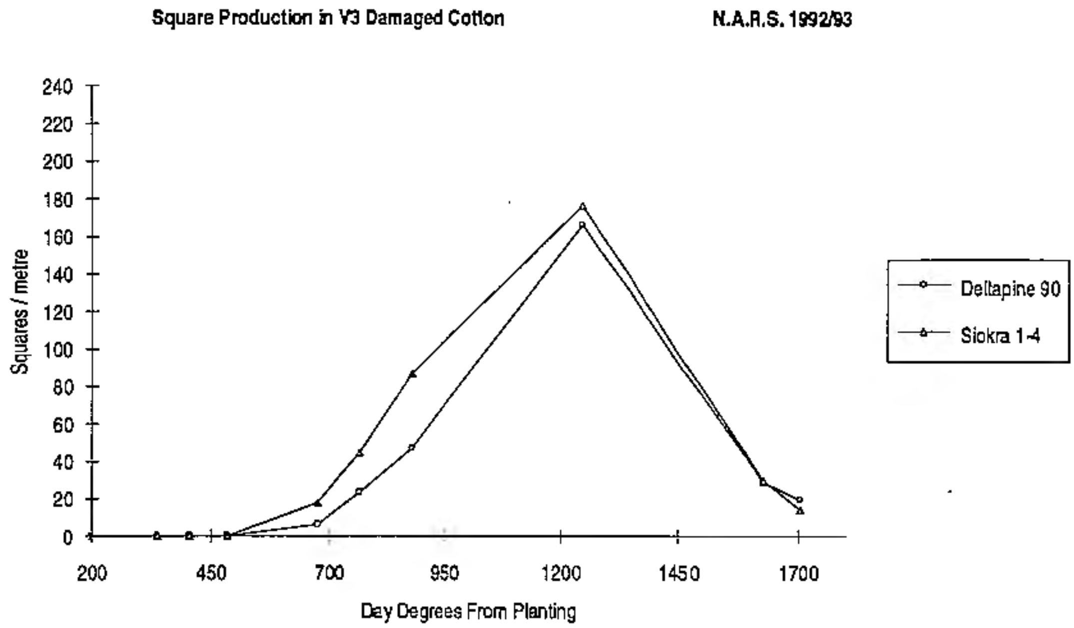
Graph No.15



Graph No.16

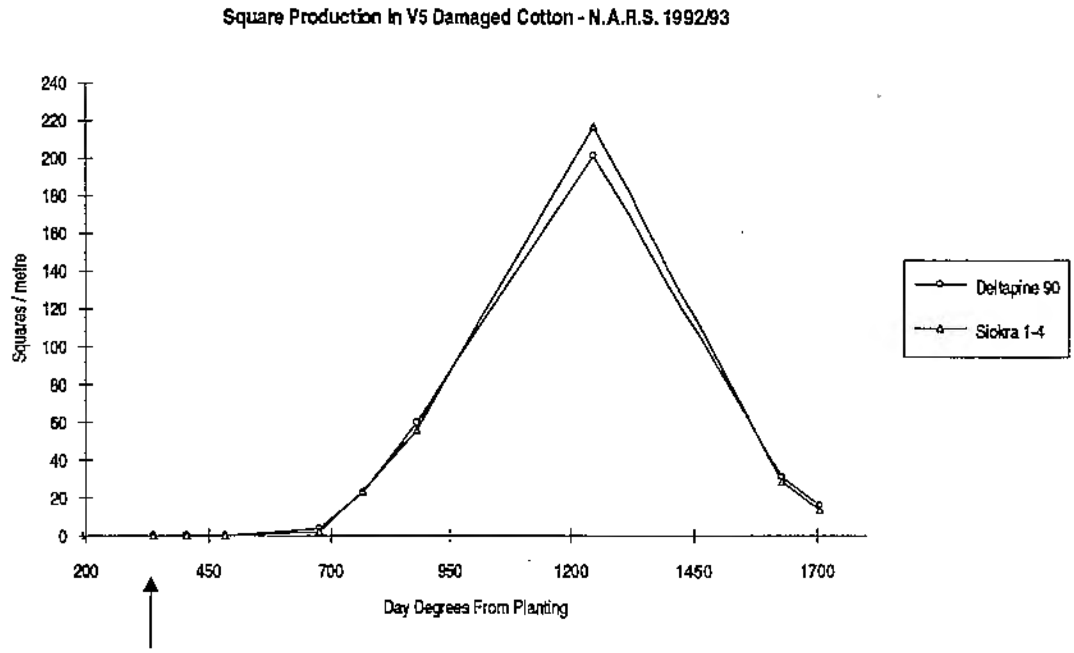


Graph No.17



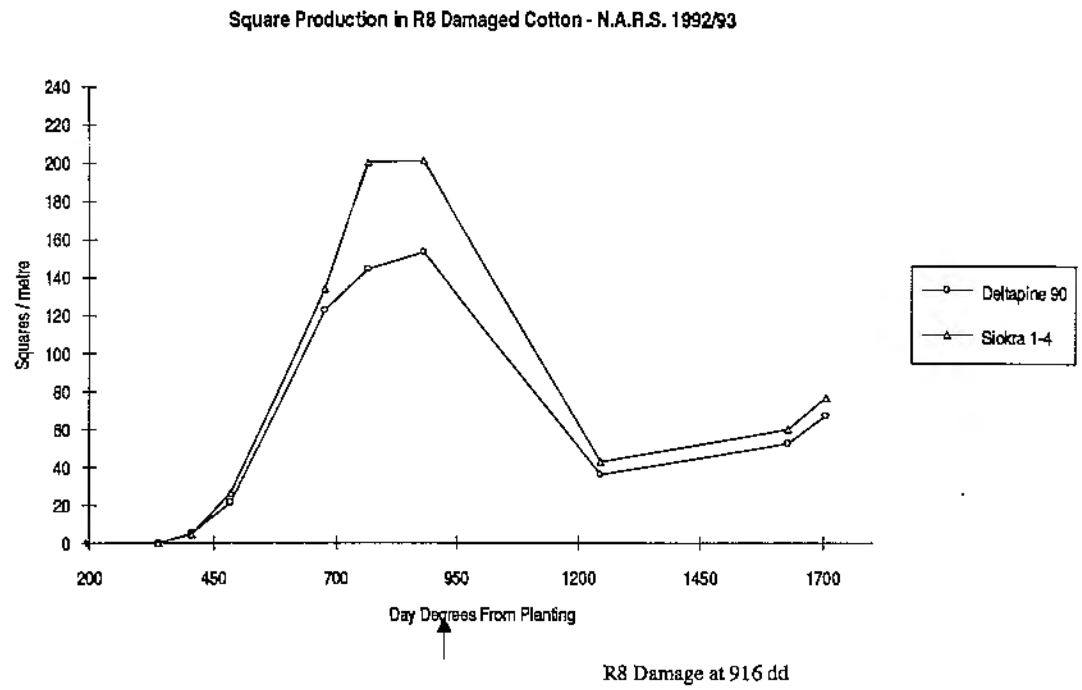
V3 Damage at 190 dd

Graph No.18

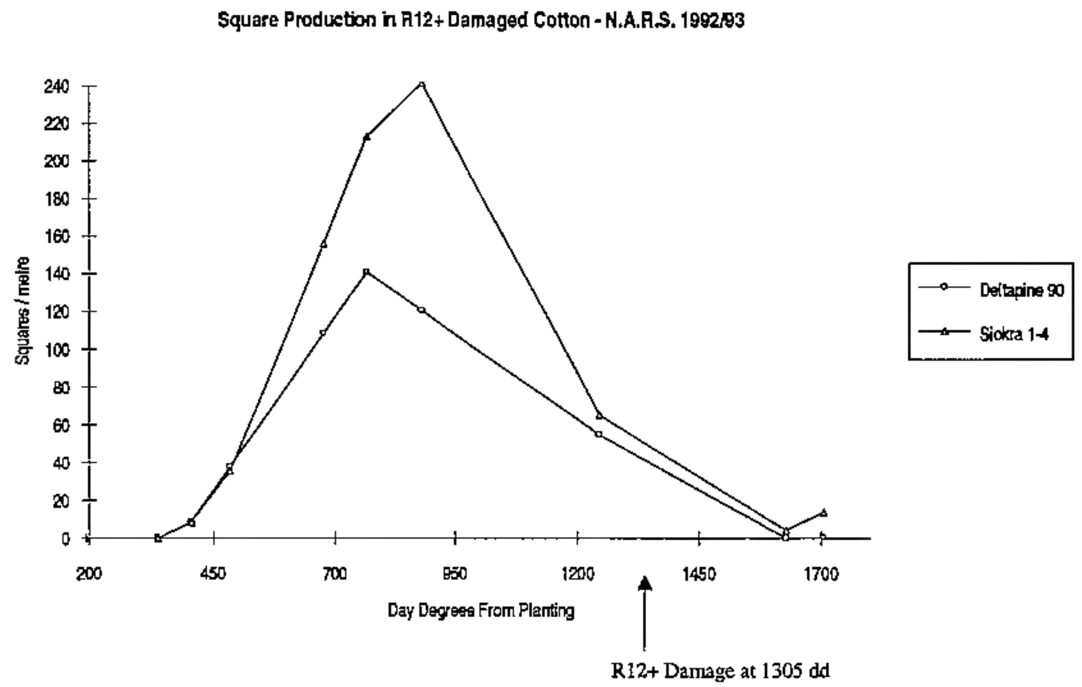


V5 Damage at 337 dd

Graph No.19

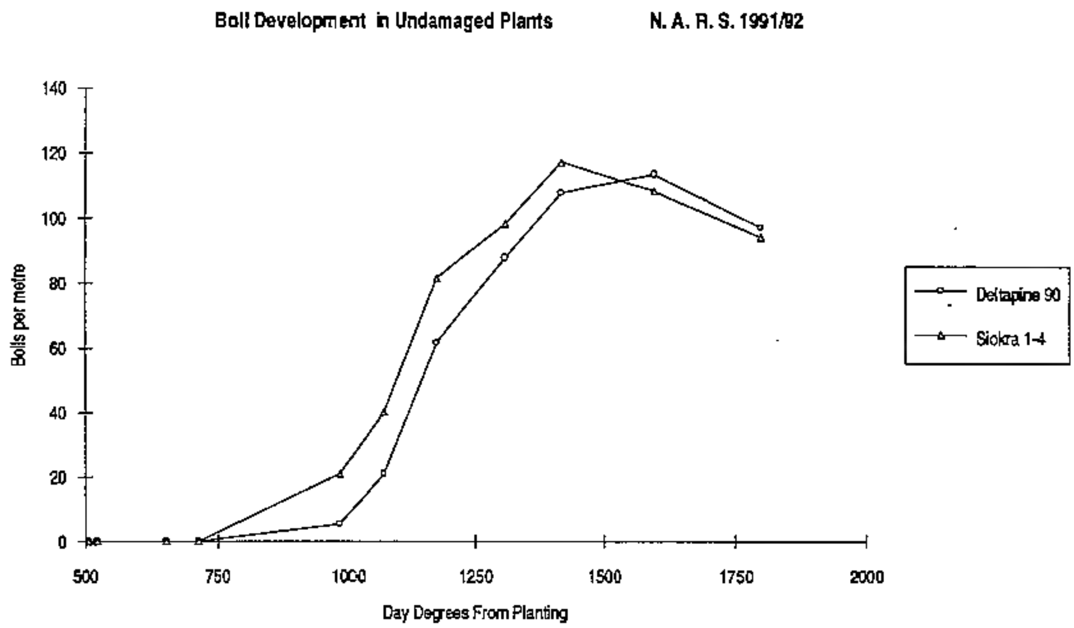


Graph No.20

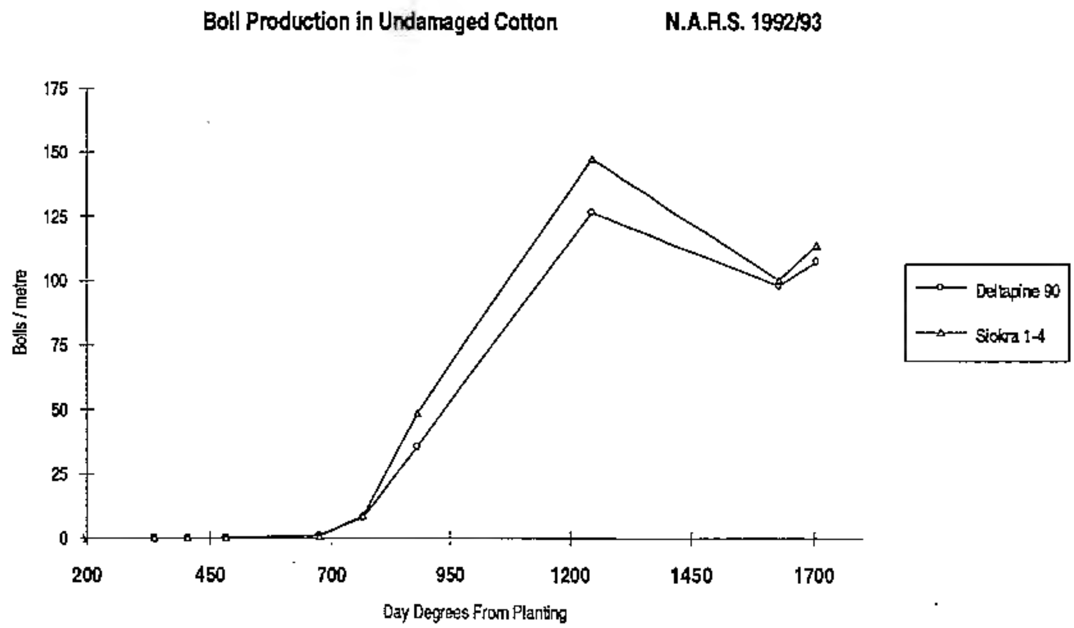


The differences in square retention or boll setting abilities of the two varieties produce very similar boll numbers at picking. The following series of graphs show the retention of bolls in hail trials at Narrabri Agricultural Research Station in 1991/92 and in 1992/93 which display pattern.

Graph No.21

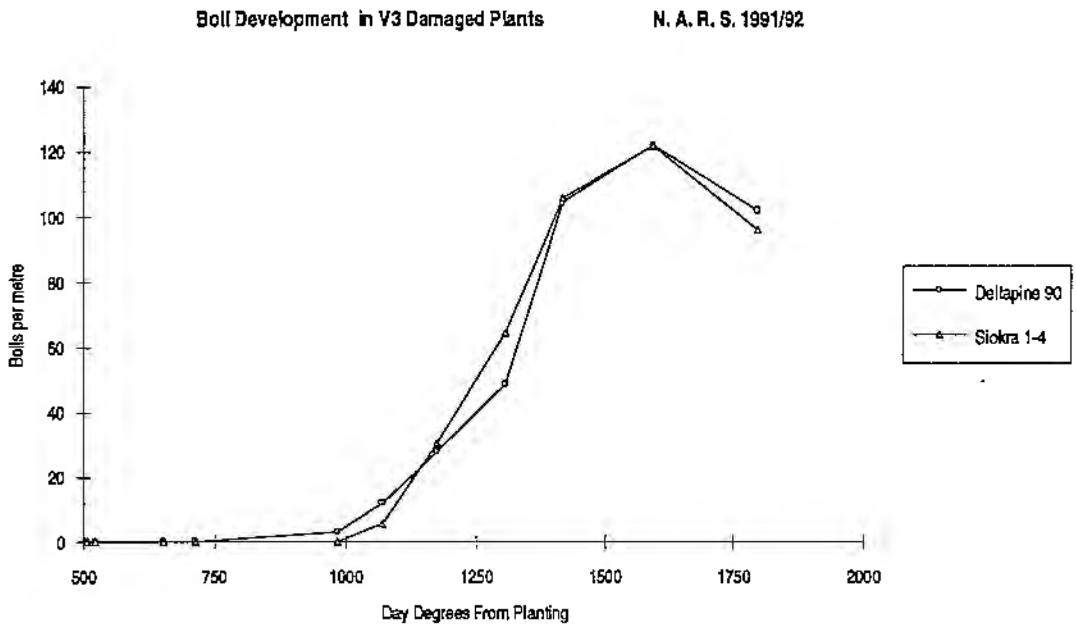


Graph No. 22



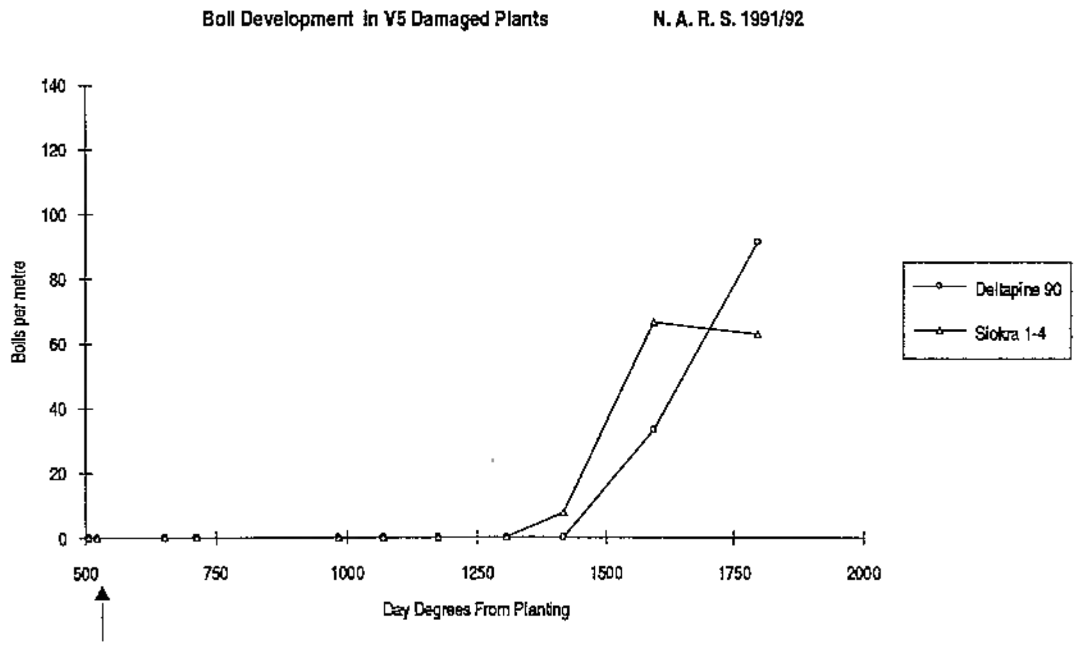
Again, the same pattern of development is displayed after simulated hail damage. Boll number do not vary significantly between varieties after damage at any of the damage dates.

Graph No.23



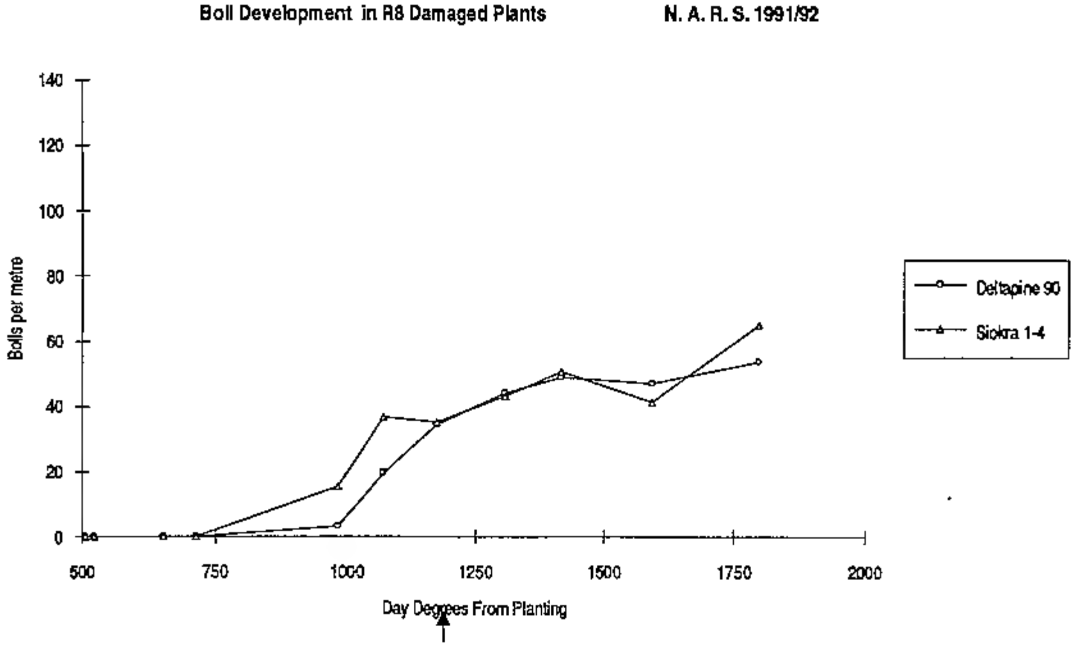
V3 Damage at 203 dd

Graph No.24



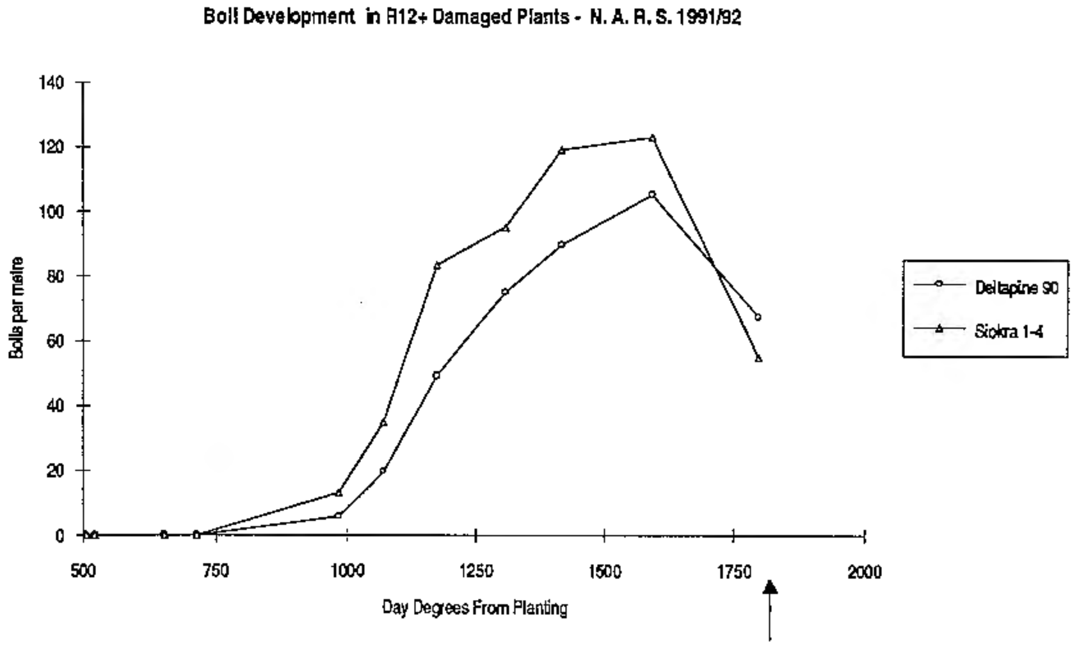
V5 Damage at 521 dd

Graph No.25



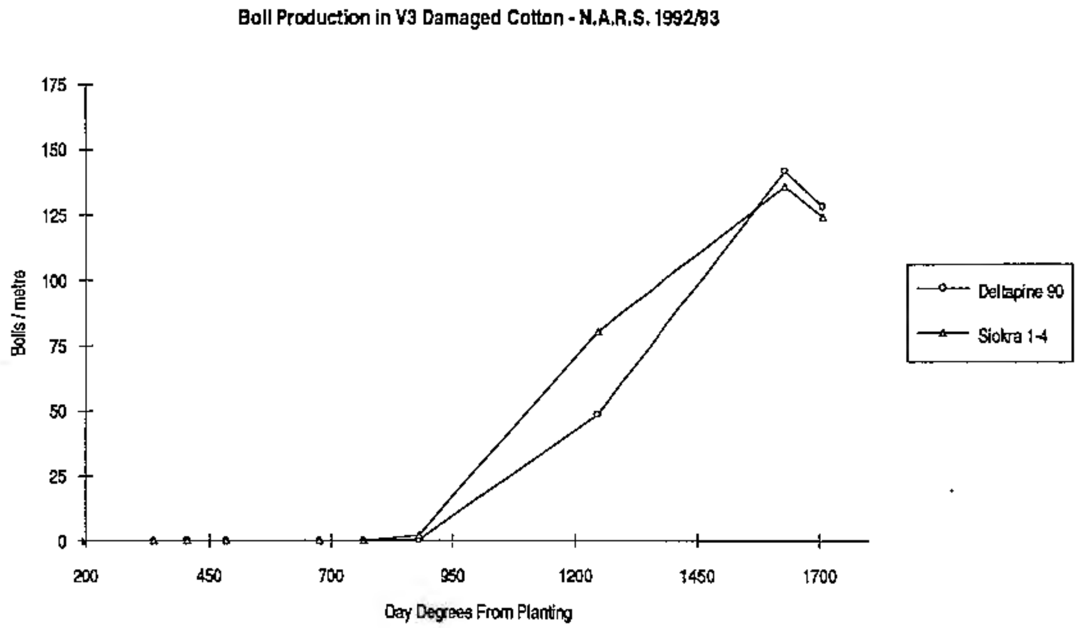
R8 Damage at 1129 dd

Graph No.26



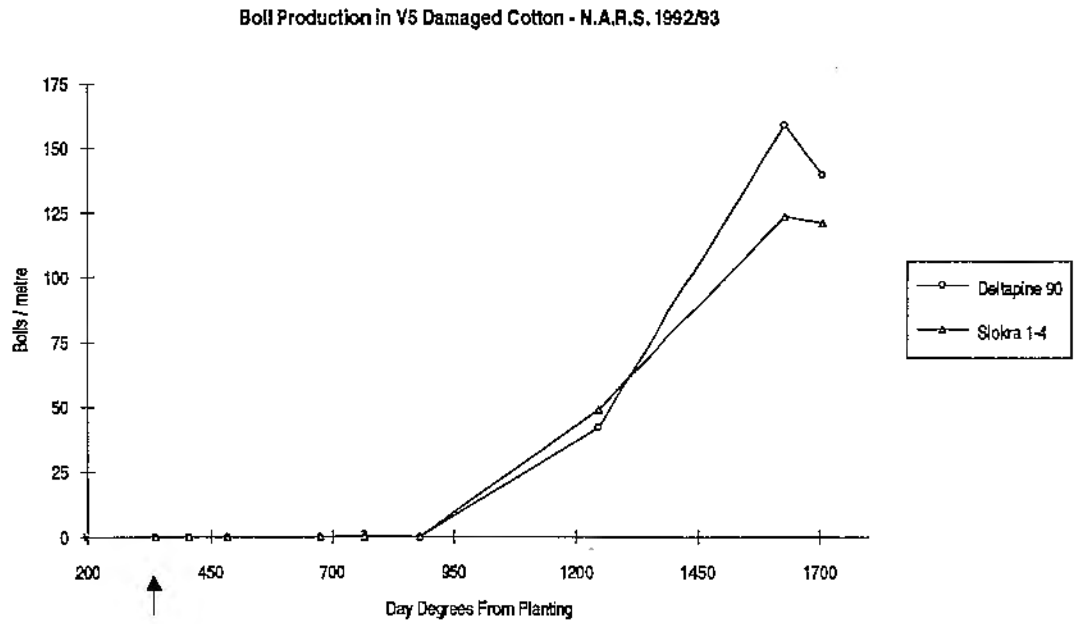
R12+ Damage at 1718 dd

Graph No.27



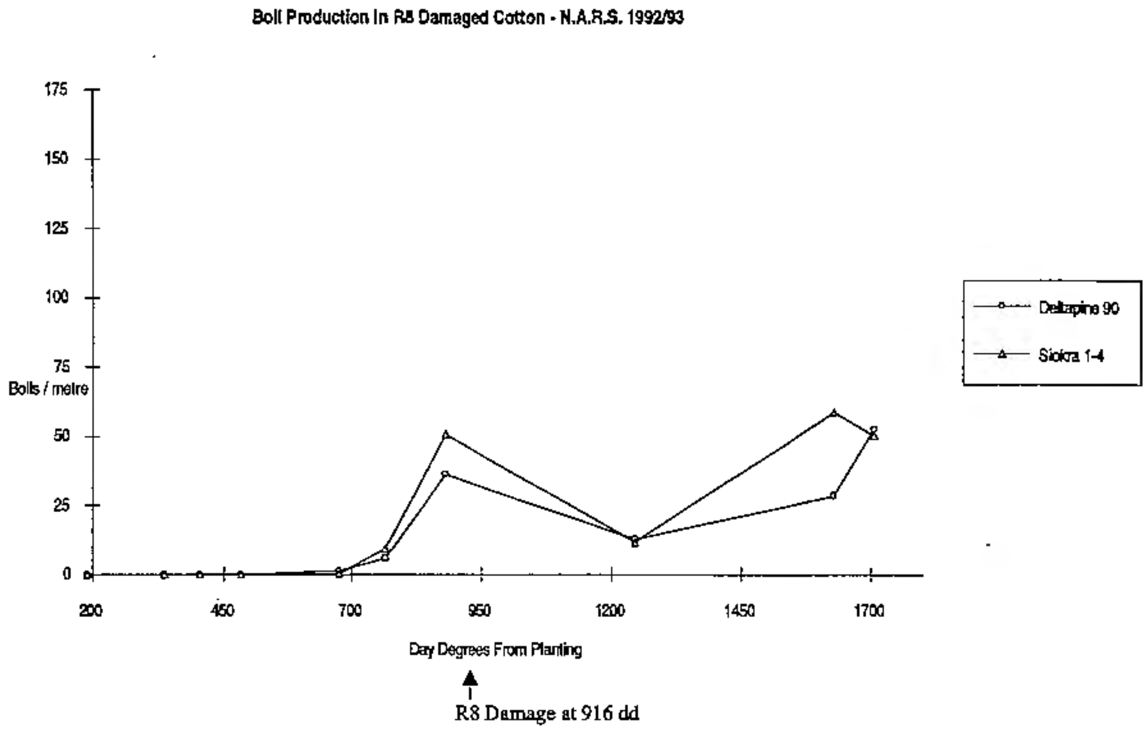
V3 Damage at 190 dd

Graph No.28

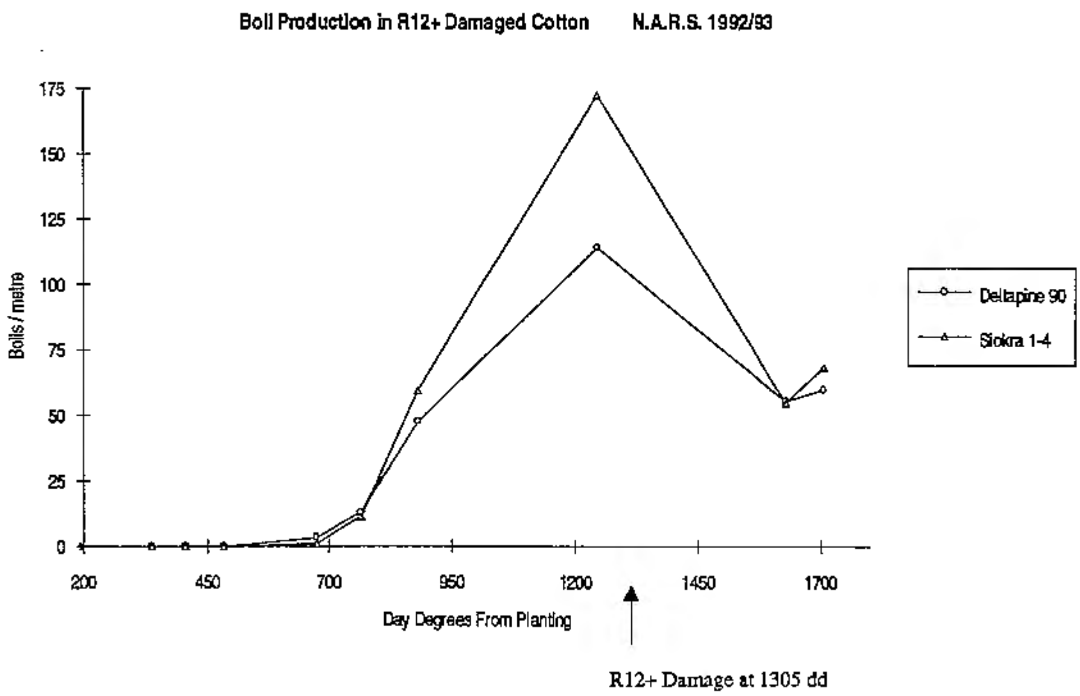


V5 Damage at 337 dd

Graph No.29



Graph No.30



Loss Assessment

The second objective of this work was to modify the loss adjustment procedures to provide a more accurate reflection of losses to growers should this work reveal that improvements in estimation of losses can be made.

What we need to keep in mind is that the loss calculation does not estimate the actual loss in yield but provides an estimate of the proportion of the plant lost at the time of damage. The percentage loss calculated is not an estimate of loss in yield. The figures quoted as actual losses in this chapter should not be compared directly with the assessed loss figures. As a general guide we will be looking at the overall size of deviations from assessed levels of damage.

In these trials we were aiming to inflict moderate and severe levels of damage. We were aiming for a 50% loss (as per the loss assessment calculation) in the small scale trial. In the large scale trials we were aiming for 30 and 60% levels of damage representing moderate and severe levels of damage.

Actual levels achieved are presented in Loss Assessment Table No.1 as ASSESSED LOSS PERCENTAGE. Loss assessments were made by the industry's loss adjusters, Robins Agriculture Pty Ltd, using actual commercial assessments of the simulated damage in the trials.

The ACTUAL LOSS in yield after damage could be calculated since undamaged control plots were included in the program. These values are presented in the following pages. As you will note there is some variation from the damage percentages we were looking for due to the difficulties encountered in simulating hail damage. In the small scale trials, the achieved levels of damage were much closer to the desired levels since damage was manually inflicted. This was a very time consuming exercise and not physically possible in the larger scale trials. Hence it was necessary to simulate damage mechanically and the desired levels of damage were not as easy to achieve. The loss assessment carried out by the loss adjusters overcomes the problem in that we were able to determine the actual level of damage inflicted and can relate this to the actual loss in yield.

Looking at the Narrabri Agricultural Research Station (See Loss Assessment Table No.1) we see that in 1991/92 when conditions following V3 stage damage were perfect for regrowth we see full recovery after an average 60% assessed loss and see a 5% - 10 % yield increase at the end of the season. This not only reflects the good growing conditions but also the fact that a crop damaged at this stage in many cases has more than sufficient time to recover to full maturity. In 1991/92 seasonal conditions were not as favourable to regrowth and we see 0.02 - 13.4 % yield loss at picking where the assessed loss was 70.7 % averaged across varieties. Hence, the less favourable conditions immediately post damage delayed and depleted regrowth but there was still sufficient time available for a substantial recovery and at picking the loss was only 6.59% (Averaged across varieties).

In 1991/92 at Narrabri Agricultural Research Station, actual loss was less than the assessed loss at all growth stages. Looking at the deviation of the actual loss from the assessed loss, assessment of loss was closest to actual loss at the R8 damage stage. No regrowth after damage at the R8 stage reached maturity therefore the amount of pickable bolls present at damage contributed to 100% of yield. There was no compensatory regrowth to take into account and hence assessed loss equalled actual loss.

Looking at the deviation of actual loss from assessed loss, we see that between the two varieties there is little difference averaged across damage dates. Therefore adjustment of the procedures need not be made on the basis of variety. The variation across damage dates in considerable but is highly dependent on climatic conditions following damage. Hence it is suggested that a factor relating the average growing conditions that can be expected after damage at a growth stage in a given area be incorporated into the loss assessment. The factor would more than likely be based on the heat units available in a given area and on their rate of accumulation.

Loss Assessment Table No.1

Loss Assessment at Narrabri Agricultural Research Station (1991/92 & 1992/93)

	Growth Stage	Assessed Loss %	Actual Loss %	Deviation	Assessed Loss %	Actual Loss %	Deviation	Average Deviation At Each Growth Stage
		Deltapine 90			Siokra 1-4			
1991/92	V3	60.08	+10.30	60.08	59.7	+5.24	64.94	62.51
	V5	57.84	39.72	18.12	57.72	37.32	20.40	19.26
	R8	47.05	38.74	8.31	44.97	43.93	1.04	4.68
	R12+	68.06	39.77	28.29	75.21	41.03	34.18	31.24
	Varietal Avg. Deviation			28.70			30.14	
1992/93		Deltapine 90			Siokra 1-4			
	V3	70.16	13.38	56.78	71.15	+0.02	71.17	63.98
	V5	44.45	20.24	24.21	46.30	16.80	29.51	26.86
	R8	56.64	81.91	-25.26	61.58	83.51	-21.94	-23.60
	R12+	68.23	44.09	24.13	59.95	46.50	13.45	18.79
	Varietal Avg. Deviation			19.97			23.05	

Extending the calculations to the large scale trials where we have the four varieties tested, again the average deviation from the assessed value is relatively constant across varieties and is relatively small. (This is except for the Auscott Narrabri in 1991/92 where in the moderate level damage treatment the deviations from the assessed loss % were large overall and due to damage simulation problems. The difference between varieties in deviations from assessed loss where DP90 and Siokra L22 show a significantly larger deviation than other varieties is not repeated in other trials.)

Looking at the average deviation from assessed loss percentage for damage at the different growth stages, we find that damage at the R8 stage is consistently underestimated across the six large scale trials. Suggesting that in the Namoi valley in these years the compensatory growth expected (by the loss adjustment procedures) for R8 stage damage plants did not occur. The regrowth was initiated but season length did not allow maturation of the regrowth. Results for other damage dates is less clear. Further investigation should be made into the interaction of climatic factors on the deviations between assessed and actual damage loss.

Loss Assessment Table No.2

Loss Assessment Auscott Narrabri Hail Trial 1990/91

Growth Stage	Level	Assessed Loss%	Actual Loss%	Deviation	Assessed Loss%	Actual Loss%	Deviation	Assessed Loss%	Actual Loss%	Deviation	Assessed Loss%	Actual Loss%	Deviation	Average Deviation at each Growth Stage
		Deltapine 90			Siokra 1-4			Siokra L22			Sicala 33			
V3	Moderate	22.63	+8.96	31.59	21.53	+11.96	33.49	26.11	0.88	25.23	16.41	+8.74	25.15	28.87
V5	Moderate	33.28	28.97	4.31	30.44	37.71	-7.27	35.00	32.22	2.78	32.70	7.3	25.40	6.30
R8	Moderate	62.87	95.78	-32.91	60.93	92.81	-31.88	59.56	88.02	-28.46	60.35	93.41	-33.06	-31.58
R12+	Moderate	63.15	56.65	6.50	65.87	50.92	14.95	59.25	51.47	7.78	68.45	55.83	12.62	10.46
	Varietal Avg. Deviation			2.37			2.32			1.84			7.53	
V3	Severe	19.69	5.53	14.16	27.02	5.04	21.98	34.42	1.41	33.01	21.71	0.45	21.26	22.60
V5	Severe	40.20	42.77	-2.57	40.45	17.69	22.76	41.71	44.48	-2.77	41.38	20.45	20.93	9.59
R8	Severe	65.86	96.78	-30.92	64.91	95.74	-30.83	64.55	96.62	-32.07	65.31	94.46	-29.15	-30.74
R12+	Severe	66.58	75.67	-9.09	50.52	76.56	-26.04	68.65	71.39	-2.74	76.65	68.4	8.25	-7.40
	Varietal Avg. Deviation			-7.10			-3.03			-1.14			5.32	

Loss Assessment Table No.3

Loss Assessment Auscott Narrabri Hail Trials 1991/92

Growth	Level	Deltapine 90 Assessed Loss%	Actual Loss%	Deviation	Siokra 1-4 Assessed Loss%	Actual Loss%	Deviation	Siokra L22 Assessed Loss%	Actual Loss%	Deviation	Sicala 33 Assessed Loss%	Actual Loss%	Deviation	Average Deviation at each Growth Stage
V3	Moderate	31.57	58.43	-26.86	47.28	47.77	-0.49	29.27	63.45	-34.18	32.27	37.22	-4.95	-16.62
V5	Moderate	43.3	76.88	-33.58	38.30	70.29	-31.99	36.64	85.47	-48.83	42.12	66.08	-23.96	-34.59
R8	Moderate	31.11	85.36	-54.25	37.34	78.26	-40.92	38.53	83.15	-44.62	47.14	85.70	-38.56	-44.59
R12+	Moderate	36.45	35.36	1.09	37.81	14.39	23.42	27.26	19.80	7.46	52.48	30.73	21.75	13.43
	Varietal Avg. Deviation			-28.40			-12.50			-30.04			-11.43	
V3	Severe	61.77	73.55	-11.78	64.4	61.64	2.76	68.42	87.65	-19.23	62.84	60.24	2.60	-6.41
V5	Severe	65.32	96.25	-30.93	80.08	86.73	-6.65	72.47	83.35	-10.88	71.62	90.15	-18.53	-16.75
R8	Severe	55.43	96.34	-40.91	50.41	93.24	-42.83	52.82	97.75	-44.93	57.13	97.82	-40.69	-42.34
R12+	Severe	51.82	22.67	29.15	56.66	20.25	36.41	49.66	45.68	3.98	59.11	34.75	24.36	23.48
	Varietal Avg. Deviation			-13.62			-2.58			-17.77			-8.07	

Loss Assessment Table No.4

Loss Assessment Auscott Narrabri Hail Trial 1992/93

Growth	Level	Deltapine 90 Assessed Loss%	Deltapine 90 Actual Loss%	Deltapine 90 Deviation	Siokra 1-4 Assessed Loss%	Siokra 1-4 Actual Loss%	Siokra 1-4 Deviation	Siokra L22 Assessed Loss%	Siokra L22 Actual Loss%	Siokra L22 Deviation	Sicala 33 Assessed Loss%	Sicala 33 Actual Loss%	Sicala 33 Deviation	Average Deviation at each Growth Stage
V3	Moderate	36.07	48.60	-12.53	33.82	32.04	1.78	67.20	52.97	14.23	38.27	28.62	9.65	3.28
V5	Moderate	29.68	32.35	-2.67	44.38	60.69	-16.31	35.21	60.36	-25.15	46.85	48.53	-1.68	-11.46
R8	Moderate	36.63	81.34	-44.71	33.68	76.36	-42.68	39.73	80.88	-41.15	40.41	82.91	-42.50	-42.76
R12+	Moderate	48.38	13.84	34.54	54.34	33.14	21.20	42.54	25.81	16.72	43.15	14.69	28.46	25.23
	Varietal Avg. Deviation			-6.34			-9.00			-8.84			-1.52	
V3	Severe	57.90	54.17	3.73	93.14	85.77	7.37	100.00	78.16	21.84	80.20	60.13	20.06	13.25
V5	Severe	76.84	49.44	27.40	69.95	47.78	22.16	75.78	70.78	5.00	40.32	69.05	-28.73	6.46
R8	Severe	46.99	67.40	-20.41	44.34	93.01	-48.67	45.02	92.26	-47.24	47.06	92.60	-45.54	-40.46
R12+	Severe	61.93	33.86	28.07	54.73	49.42	5.31	53.60	52.93	0.67	52.98	48.75	4.24	9.57
	Varietal Avg. Deviation			9.70			-3.46			-4.93			-12.49	

Loss Assessment Table No.5

Loss Assessment "Merinda West" Hail Trial 1990/91

Growth	Level	Deltapine 90 Assessed Loss%	Actual Loss%	Deviation	Siokra 1-4 Assessed Loss%	Actual Loss%	Deviation	Siokra L22 Assessed Loss%	Actual Loss%	Deviation	Sicala 33 Assessed Loss%	Actual Loss%	Deviation	Average Deviation at each Growth Stage
V3	Moderate	25.23	12.45	12.78	21.98	25.50	-3.52	21.62	13.94	7.68	20.70	12.67	8.03	6.24
V5	Moderate	39.69	61.12	-21.43	42.37	63.08	-20.71	45.55	69.83	-24.28	40.23	75.03	-34.80	-25.31
R8	Moderate	64.11	88.92	-24.81	61.69	90.73	-29.04	60.60	88.99	-28.39	60.87	73.79	-12.92	-23.79
R12+	Moderate	44.69	27.31	17.38	52.52	57.32	-4.80	54.01	50.77	3.24	58.50	37.19	21.31	9.28
	Varietal Avg. Deviation			-4.02			-14.52			-10.44			-4.59	
V3	Severe	27.18	7.8	19.38	31.17	21.05	10.12	31.18	26.29	4.89	27.72	14.21	13.51	11.97
V5	Severe	51.11	63.1	-11.99	64.29	86.28	-21.99	57.17	87.96	-30.79	53.90	86.41	-32.51	-24.32
R8	Severe	74.38	94.91	-20.53	70.79	93.89	-23.10	72.56	94.06	-21.50	75.23	94.67	-19.44	-21.14
R12+	Severe	61.49	50.30	11.19	55.17	64.13	-8.96	60.42	63.54	-3.12	56.72	48.21	8.51	1.91
	Varietal Avg. Deviation			-0.49			-10.98			-12.63			-7.48	

Loss Assessment Table No.6

Loss Assessment "Merinda West" Hail Trial 1991/92

Growth	Level	Deltapine 90 Assessed Loss%	Actual Loss%	Deviation	Siokra 1-4 Assessed Loss%	Actual Loss%	Deviation	Siokra L22 Assessed Loss%	Actual Loss%	Deviation	Sicala 33 Assessed Loss%	Actual Loss%	Deviation	Average Deviation at each Growth Stage
V3	Moderate	**	**	**	**	**	**	**	**	**	**	**	**	**
V5	Moderate	90.18	88.05	2.13	83.14	68.92	14.22	75.09	68.81	6.28	71.47	70.06	1.41	6.01
R8	Moderate	52.57	46.76	5.81	42.97	81.85	-38.88	51.76	86.31	-34.55	48.71	40.42	8.29	-14.83
R12+	Moderate	45.38	+0.85	46.23	44.44	7.59	36.85	43.59	18.76	24.83	44.20	+16.73	27.47	33.85
	Varietal Avg. Deviation			18.06			4.06			-1.15			12.39	
V3	Severe	**	**	**	**	**	**	**	**	**	**	**	**	**
V5	Severe	100	99.80	0.20	99.06	97.26	1.80	95.78	95.20	0.58	99.85	62.92	36.93	9.88
R8	Severe	63.21	95.80	-32.59	59.07	94.14	-35.07	59.15	96.84	-37.69	60.05	96.88	-36.83	-35.55
R12+	Severe	63.53	17.43	46.10	53.83	17.42	36.41	53.01	24.90	28.11	58.61	3.59	55.02	41.41
	Varietal Avg. Deviation			4.57			1.05			-3.00			18.37	

NB: Marked treatments (**) were not treated due to wet weather conditions and can be included as controls.

Loss Assessment Table No.7

Loss Assessment "Merinda West" Hail Trial 1992/93

Growth	Level	Deltapine 90 Assessed Loss%	Deltapine 90 Actual Loss%	Deltapine 90 Deviation	Siokra 1-4 Assessed Loss%	Siokra 1-4 Actual Loss%	Siokra 1-4 Deviation	Siokra L22 Assessed Loss%	Siokra L22 Actual Loss%	Siokra L22 Deviation	Sicala 33 Assessed Loss%	Sicala 33 Actual Loss%	Sicala 33 Deviation	Average Deviation at each Growth Stage
V3	Moderate	36.97	16.67	20.31	50.63	30.64	19.99	56.26	30.87	25.39	61.62	49.82	11.80	19.37
V5	Moderate	46.69	49.37	-2.68	66.70	70.98	-4.29	56.17	64.39	-8.22	59.68	59.60	0.08	-3.78
R8	Moderate	44.44	40.95	3.49	48.31	65.04	-16.73	51.53	77.31	-25.78	37.41	81.41	-44.01	-20.75
R12+	Moderate	50.91	41.95	8.96	47.20	47.36	-0.16	48.49	42.16	6.33	50.67	39.57	11.10	6.56
	Varietal Avg. Deviation			7.52			-0.30			-0.57			-5.26	
V3	Severe	36.51	12.40	24.11	73.86	43.30	30.56	92.13	81.26	10.88	60.98	55.24	5.74	17.82
V5	Severe	86.40	71.69	14.70	65.60	87.32	-21.72	92.93	81.79	11.14	95.27	83.28	11.99	4.03
R8	Severe	57.68	86.17	-28.50	53.39	82.68	-29.29	57.27	86.84	-29.56	50.16	89.22	-39.06	-31.60
R12+	Severe	64.37	45.95	18.43	50.26	54.37	-4.11	52.87	60.38	-7.51	53.28	49.08	4.20	2.75
	Varietal Avg. Deviation			7.18			-6.14			-3.77			-4.28	

COTTON RESEARCH & DEVELOPMENT CORPORATION PROJECT - CDL1C
REGROWTH CAPABILITIES OF AUSTRALIAN COTTON VARIETIES AFTER DAMAGE BY HAIL

SUPPLEMENTARY REPORT

PREPARED BY BRENT A DEMNAR - MANAGING DIRECTOR, ROBINS AGRICULTURE - CHARTERED LOSS ADJUSTERS

The Cotton Trials conducted over the period 1990 to 1993, were designed to document the varying responses of existing commercially grown cotton varieties to hail damage, with a view to identifying any significant varietal differences in their recovery.

In addition to the industry interest in variety response, the trials were also designed to validate the existing procedures used for loss adjustment purposes. In this regard, the data collected was to be considered in the light of the methodology of the current Australian Cotton Industry Hail Insurance Loss Assessment Procedures, for the purpose of establishing whether, and to what extent, the procedures should be modified to incorporate varietal differences, if they were identified.

On the basis of the results obtained from the trials, the clear indication is that in terms of hail damage recovery, there is no varietal difference of any significance, beyond the normal difference inherent in the varieties themselves. In view of this, it has been positively concluded that the existing loss assessment procedures do not require varietal modification. However, it was not possible to further validate the assessment procedures, given that they are designed to measure the loss of plant parts at a specific point in time, rather than calculate the resultant impact on crop yield.

As a result, no relativity existed to undertake comparative analysis of yields achieved as a consequence of simulated hail damage with the actual loss as assessed. To the extent that the existing procedures classify growth stage and account for the loss of plant parts during the growth cycle, the procedures are quite soundly based.

However, the trial results have identified the extent to which a crops ability to recover from the affects of hail damage is governed by seasonal factors, and it is in relation to this issue that further procedure development should be focused.

What must be understood is that the procedures currently in use are only designed to measure the percentage of the plant destroyed as a result of hail damage as at a given point in time, and do not claim to be capable of measuring the loss in subsequent yield. Indeed, the Industry Hail Insurance cover only provides an indemnity in relation to the duplication in historical production expenses, and does not provide compensation for any yield reduction which might, or might not occur.

Therefore, while the current procedures achieve the measurement for which they were designed, the trial results provide a source of quantification of an alternate exposure, for which there is neither insurance protection, nor objective assessment methods available.

As loss adjusters, our interest is in establishing whether a technique can be designed to deal with the variation in seasonal conditions, where such variations either allow for a full crop recovery, or result in a yield reduction, as a direct consequence of hail damage.

Given that the existing procedures only allow for the direct physical loss to be measured, to achieve a relativity with seasonal conditions, a second dimension must be added which is compatible with the first measurement taken. That is to say that a method must be established which recognises that stem and limb damage will recover if seasonal conditions are favourable, and enables the rate of recovery to be objectively determined.

The trial results have presented us with data which serves to correlate the impact upon crop yields of varying seasonal conditions and this will allow us to understand the relationship between seasonal conditions and crop growth and recovery, on the basis of which, an approach to the design of end yield assessment could be possible.

Our belief is that the assessment result currently produced must be discounted to take account of good growing conditions after a loss, or loaded where insufficient growth days remain to allow for recovery. As the trial results show that crop recovery is maximised in good growing conditions, and conversely, is impaired in poor growing conditions, an assessment of yield impact can only be determined after the weather to which the crop was exposed, and the growth days available, can be fully documented.

During the course of preliminary work done to date, we have considered the application of a simple formula based on growth days subsequent to hail damage, and are now examining the manner in which heat units can be factored into the equation.

The result could be that rather than confine our assessment to physical loss at the time of damage, we might well be in a position to offer totally objective yield based assessments, representing a significant shift in focus away from interim losses to the yield affect.

The trials have presented us with a unique opportunity to collect an enormous quantity of data on which to base the further development of loss assessment procedures, and we are grateful to the Trial Co-ordinator Karyl-Lee West for her efforts, and her ongoing assistance and co-operation.

APPENDIX A:

Summary of Planting, Damage Simulation and Picking Dates

HAIL TRIALS 1990/91 - 1992/93

TRIAL SITE	DATE OF SOWING	DATE OF DAMAGE 1	DATE OF DAMAGE 2	DATE OF DAMAGE 3	DATE OF DAMAGE 4	DATE OF FINAL PICK
Auscott Narrabri 1990/91	29/9/90	14/11/90	13/12/90	13/1/91	15/2/91	17/4/91
Auscott Narrabri 1991/92	3/10/91	11/11/91	29/11/91	16/1/92	2/3/92	29/3/92
Auscott Narrabri 1992/93	9/10/92	25/11/92	3/12/92	15/1/93	12/2/93	18/4/93
Carson's 1991/90	13/10/90	29/11/90	12/12/90	5/2/91	27/2/91	17/4/91
Merinda West 1991/92	10/10/91	Not applied	27/11/91	24/1/92	2/3/92	8/4/92
Merinda West 1992/93	22/10/92	30/11/92	15/12/92	27/1/93	27/2/93	29/4/93
Narrabri Ag. Res. Station 1991/92	9/10/91	1/11/91	29/11/91	17/1/92	2/3/92	21/4/92
Narrabri Ag. Res. Station 1992/93	8/10/92	15/11/92	30/11/92	14/1/93	5/2/93	23/4/93

GROWTH STAGES OF CROPS AT DAMAGE SIMULATIONS:

YEAR	DAMAGE 1	DAMAGE 2	DAMAGE 3	DAMAGE 4
1990/91	V3	R1	R8	R12+
1991/92	V3	V5	R9	R12+
1992/93	V3	V5	R8	R12+

Appendix B:

Fruit Development And Vegetative Regrowth Monitoring.

A. Stand counts were used to determine average plant populations per variety. In the small scale trial plant population was thinned to produce a uniform stand of 8-10 plants per metre in 1991/92 whereas in 1992/93, the plant population was considered to be suitably uniform.

B. Fruit counts were carried out at two weekly intervals in the large scale trials to determine fruiting patterns before and after damage. (One metre count per plot.) Counts were made weekly in the case of the smaller scale trial.

Fruiting forms were defined as follows:-

Square - Flower bud from 0.5cm in size to yellow flower.

Small Green boll - Pink flower to unopened boll no larger than 2 cm in diameter.

Large Green Boll - Unopened boll from 2cm in diameter up to mature size.

Open boll - mature boll, opened to reveal lint.

Appendix C:

Lint Yield Determinations

Sequential picking was commenced at the stage at which approximately 25% of bolls were open at a given trial site. Any boll within the sample metre which was open on the sequential pick day would be picked. All samples would be dried to equivalent moisture contents by dehydration ovens (50 degrees Celsius for 24 hours) and seed cotton weight determined by weighing. Samples would then be ginned and lint produced weighed to allow calculation of lint turnout percentages. Sequential hand picking was carried out in both large and small scale trials.

Overall final lint yield was determined by a mechanical pick using a single row cotton picker, for a 10 metre square (10 metre length of row)in the large scale trials. Sub-samples of seed cotton were dried to equal moisture content, ginned on an experimental size 10-saw gin and lint weighed to determine turnout percentages and hence allow calculation of commercial yield equivalents.

Fibre quality was measured by Auscott Ltd. The following parameters of fibre quality were measured and are analysed-

<u>Length 1</u> - The point where 50% of the fibres are longer than the given length.

<u>Length 2</u> - The classer's length which is used to sell the cotton.

<u>Uniformity Ratio</u> - The ratio of Length 1 over Length 2 (x 100)

<u>Strength</u> - Grams/tex

<u>Elongation</u> - A measurement of elasticity using a % change in fibre length.

<u>Micronaire</u> - measurement of 'fineness' or diameter of fibre.

Of interest, but not presented, is <u>Grade</u>. Grade is a value describing the colour and class of the fibre. Grading systems are variable between cotton processors.

Analyses will be of Length 2, Strength and Micronaire. These parameters being of prime importance in marketing.

APPENDIX D:

Climatic Patterns For 1990/91 to 1991/92 Cotton Seasons

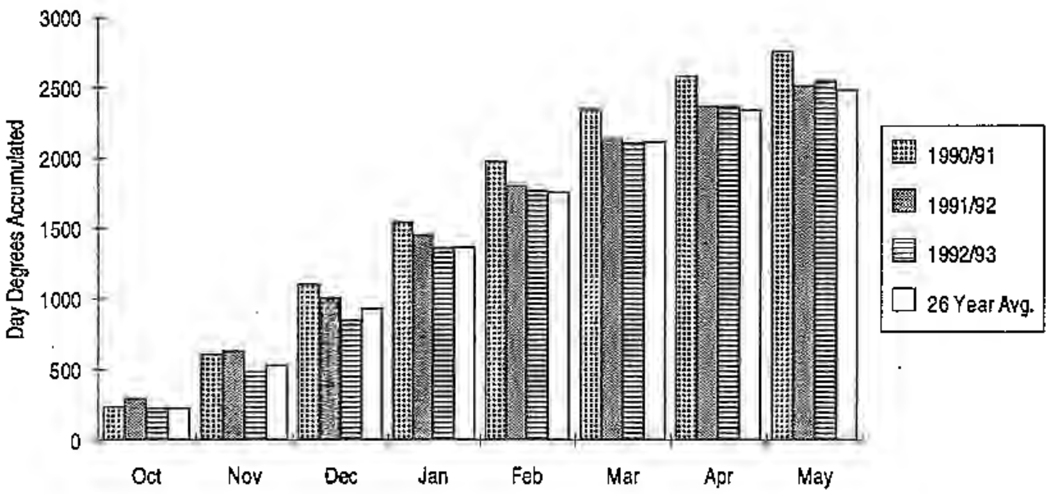
Summary of Weather Data for Cotton Seasons 1990/91 to 1992/93

	rain (mm)	evap (mm)	max (C)	min (C)	wind	radn (Langley)	soil (C)	RH (%)	daydeg	Accumulated daydeg
1990/91 Season										
Oct	58.8	7	26.1	11.3	199	529	15.6	52	234	234
Nov	0.2	8.8	32.4	16.1	210	638	17.6	57	368	602
Dec	27.2	11.7	36.1	20.4	220	642	19.6	40	504	1106
Jan	104.8	8.5	32.6	19.6	186	555	23.6	47	437	1543
Feb	55.4	8.9	34.2	20.5	158	576	23.9	54	430	1973
Mar	58.8	8.7	32	15.6	164	519	21.2	46	372	2345
Apr	0	6.3	26.9	10.3	139	425	18	46	236	2581
May	177.8	4	22.4	11	163	275	15.6	65	170	2751
	Total	Total	Avg.	Avg.	Avg.	Total	Avg.	Avg.	Total	
	483	63.9	30.34	15.6	179.89	4159	19.39	50.88	2751	
1991/92 Season										
Oct	18	8.2	29.2	13.2	215	534	16.4	44	294	294
Nov	67.4	9	30.1	16.3	210	547	18.7	48	336	630
Dec	121.4	9.9	30.9	17.5	223	593	19.9	47	378	1008
Jan	7	10.4	34	18.7	215	617	21.7	45	445	1453
Feb	115.4	8.1	30.4	17.4	223	495	20.7	63	345	1798
Mar	2.6	8.1	30.9	14.1	180	510	19	59	331	2129
Apr	54.6	5.3	26.9	11.3	151	359	15	65	235	2364
May	15.2	3.5	21.6	8.2	135	271	10.6	67	149	2513
	Total	Total	Avg.	Avg.	Avg.	Total	Avg.	Avg.	Total	
	401.6	62.5	29.25	14.5875	194	3926	17.75	54.75	2513	
1992/93 Season										
Oct	43.5	6.7	25.3	10.7	214	496	16.4	54	223	223
Nov	92.1	6.6	27	13.6	214	551	19.4	52	261	484
Dec	56.2	8.4	29.9	17.7	221	553	21.5	58	366	850
Jan	41.7	9.7	35.3	21.6	201	618	23	65	510	1360
Feb	27.6	8.5	33.3	19.3	172	574	22.3	65	402	1762
Mar	20.1	8.7	29.9	15.8	245	507	20.4	63	341	2103
Apr	0	6.3	28.4	12.2	157	384	15.4	56	262	2365
May	27	3.9	23.2	9.5	162	276	13.2	69	184	2549
	Total	Total	Avg.	Avg.	Avg.	Total	Avg.	Avg.	Total	
	308.2	58.8	29.0375	15.05	198.25	3959	18.95	60.25	2549	

<u>26 Year Climatic Average</u>

	rain (mm)	evap (mm)	max (C)	min (C)	wind	radn (Langley)	soil (C)	RH (%)		Accumulated daydeg
	51.4	6.7	25.9	12	215	493	17.6	57	223	223
Oct	57.5	8.9	29.5	15.1	235	570	21.3	53	308	531
Nov	54.7	10.5	32.2	17.8	250	605	24.4	54	403	934
Dec	103.9	9.5	32.5	19.2	240	590	25.6	60	430	1364
Jan	56.6	8.7	32.5	19.3	221	547	25.5	63	390	1754
Feb	50.2	7.6	30.1	16.8	198	484	23.2	62	355	2109
Mar	28.7	5.6	26.4	12.2	173	380	18.8	63	228	2337
Apr	43.5	3.6	21.2	7.9	157	278	14.1	70	142	2479
May										
	Total	Total	Avg.	Avg.	Avg.	Total	Avg.	Avg.	Total	
	446.5	61.1	28.7875	15.0375	211.125	3947	21.313	60.25	2479	

Day Degree Accumulation for Cotton Seasons 1990/91 to 1992/93



Appendix E:

Lint Quality Data

Lint Quality Table No. 3A

Average Effect of Hail Damage on Lint Quality

			Undamaged	Moderate Damage	Severe Damage		
Length	Auscott Narrabri	1990/91	1.192	1.199	1.204	*	l.s.d. = 0.01006
		1991/92	1.129	1.123	1.136	n.s	
		1992/93	1.187	1.210	1.195	**	l.s.d. = 0.00141
		Avg.	1.169	1.177	1.178		
	Merinda West	1990/91	1.119	1.132	1.144	***	l.s.d. = 0.01207
		1991/92	1.183	1.174	1.179	n.s.	
		1992/93	1.199	1.192	1.177	*	l.s.d. = 0.01408
		Avg.	1.167	1.166	1.167		
	Narrabri Ag. Res.	1991/92	1.191	1.179		n.s.	
	Station	1992/93	1.148	1.164		n.s.	
		Avg.	1.170	1.172			
	Overall Average		1.169	1.172	1.173		
Strength	Auscott Narrabri	1990/91	29.620	29.450	29.130	n.s.	
		1991/92	27.490	27.620	28.640	n.s.	
		1992/93	31.160	30.860	30.770	n.s.	
		Avg.	29.423	29.310	29.513		
	Merinda West	1990/91	29.490	28.670	28.550	n.s.	
		1991/92	28.600	28.660	28.690	n.s.	
		1992/93	31.310	31.110	29.880	***	l.s.d. = 0.696
		Avg.	29.800	29.480	29.040		
	Narrabri Ag. Res.	1991/92	26.870	28.210		*	l.s.d. = 0.0.1344
	Station	1992/93	29.020	29.760		n.s.	
		Avg.	27.945	28.985			
	Overall Average		29.195	29.293	29.277		

Table No. 3B:

Average Effect of Damage On Lint Quality

			Undamaged	Moderate Damage	Severe Damage	
Micronaire	Auscott Narrabri	1990/91	4.152	3.760	3.608	*** l.s.d. = 0.1328
		1991/92	3.804	3.556	3.609	*** l.s.d. = 0.1066
		1992/93	3.598	3.742	3.802	** l.s.d. = 0.1268
		Avg.	3.851	3.686	3.673	
	Merinda West	1990/91	4.748	3.985	3.944	*** l.s.d. = 0.1368
		1991/92	3.900	3.848	3.770	
		1992/93	3.650	3.474	3.454	** l.s.d. = 0.0125
		Avg.	4.099	3.769	3.723	
	Narrabri Ag. Res. Station	1991/92	4.400	4.334		n.s.
		1992/93	4.536	4.172		* l.s.d. = 0.2972
		Avg.	4.468	4.253		
	Overall Average		4.099	3.859	3.698	

Lint Quality Table No. 4A

Average Quality Data For Lint Hail Trials 1990/91 to 1992/93 - Date Effect

	Growth Stage at Damage		Control	V3	V5	R8	R12+		
Length	Auscott Narrabri	1990/91	1.192	1.192	1.201	1.194	1.206	*	l.s.d. = 0.0101
		1991/92	1.129	1.144	1.114	1.132	1.127	***	l.s.d. = 0.0127
		1992/93	1.187	1.211	1.196	1.192	1.191	n.s.	
		Avg.	1.169	1.182	1.170	1.172	1.175		
	Merinda West	1990/91	1.119	1.128	1.156	1.130	1.114	***	l.s.d. = 0.0142
		1991/92	1.183	1.180	1.172	1.181	1.181	n.s.	
		1992/93	1.199	1.186	1.177	1.192	1.202	*	l.s.d. = 0.0170
		Avg.	1.167	1.165	1.169	1.168	1.166		
	Narrabri Ag. Res. Station	1991/92	1.191	1.193	1.179	1.182	1.188	n.s.	
		1992/93	1.148	1.174	1.173	1.121	1.156	**	l.s.d. = 0.0284
		Avg.	1.170	1.183	1.176	1.152	1.172		
	Overall Average		1.169	1.176	1.171	1.165	1.171		
Strength	Auscott Narrabri	1990/91	29.620	29.590	28.710	30.290	29.000	***	l.s.d. = 0.7706
		1991/92	27.490	29.320	27.640	27.120	27.590	*	l.s.d. = 1.4845
		1992/93	31.160	31.540	31.380	30.480	30.320	**	l.s.d. = 0.7321
		Avg.	29.423	30.150	29.243	29.297	28.970		
	Merinda West	1990/91	29.490	29.920	28.290	28.640	28.770	*	l.s.d. = 1.1620
		1991/92	28.600	28.400	28.730	28.760	28.720	n.s.	
		1992/93	31.310	30.760	29.960	31.180	31.180	**	l.s.d. = 0.8112
		Avg.	29.800	29.693	28.993	29.527	29.557		
	Narrabri Ag. Res. Station	1991/92	26.870	27.270	28.390	27.630	26.860	n.s.	
		1992/93	29.020	29.990	30.110	28.750	28.720	n.s.	
		Avg.		28.630	29.250	28.190	27.790		
	Overall Average		29.195	29.195	29.195	29.195	29.195		

Lint Quality Table No.4B:

Average Quality Data For Lint Hail Trials 1990/91 to 1992/93 - Date Effect

	Growth Stage at Damage		Control	V3	V5	R8	R12+		
Micronaire	Auscott Narrabri	1990/91	4.152	4.191	3.488	3.953	3.727	***	l.s.d. = 0.1551
		1991/92	3.804	3.536	3.229	4.122	3.739	***	l.s.d. = 0.1233
		1992/93	3.598	3.417	3.408	3.878	4.153	***	l.s.d. =0.1474
		Avg.	3.851	3.715	3.375	3.984	3.873		
	Merinda West	1990/91	4.748	4.603	3.894	4.258	4.148	***	l.s.d. = 0.158
		1991/92	3.900	3.889	3.791	3.889	3.789	n.s.	
		1992/93	3.650	3.351	3.260	3.792	3.702	***	l.s.d. = 0.1446
		Avg.	4.099	3.948	3.648	3.980	3.880		
	Narrabri Ag. Res. Station	1991/92	4.400	4.488	4.150	4.500	4.331	*	l.s.d. = 0.280
		1992/93	4.536	4.350	4.063	4.619	4.385	n.s.	
		Avg.	4.468	4.419	4.107	4.560	4.358		
	Overall Average		4.099	3.978	3.660	4.126	3.997		