SIMULATED EARLY SEASON WEATHER DAMAGE EFFECTS ON COTTON GROWTH AND YIELD

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Abstract

Wind and hail events commonly damage young cotton seedlings. This reduces vigor and calls into question a replanting decision. Quantitative information that relates damage to young seedlings to yield is needed to make informed production management decisions. Simulated weather damage studies using young cotton seedlings were conducted under full irrigation in 1996 and under limited irrigation in 1997. The treatments included removing (a) no leaves removed - Control, (b) one cotyledon -C, (c) two cotyledons -2C, (d) all true leaves -TL, (e) one cotyledon and all true leaves -C-TL, and (f) two cotyledons and all true leaves -2C-TL. Cotton seedlings had leaf areas of 362 cm^2/m^2 and 592 cm^2/m^2 when treatments were imposed in 1996 and 1997, respectively. The difference in leaf area between years was due to greater true leaf area in 1997 than in 1996. Seedlings had between 2 and 3 mainstem nodes each year when weather damage treatments were applied. Plant survival was significantly reduced by the most severe treatment, -2C-TL, in both years. Water supply differences between years did not affect vegetative development prior to four weeks after treatments were applied. Lint yield was reduced by the most severe simulated weather damage treatment, -2C-TL, in both years. In 1996 when water was not limited there was a strong relationship between leaf area immediately after treatments were applied and lint yield; however, the limited water supply in 1997 diminished the relationship between post treatment leaf area and yield.

Introduction

Physical damage from weather events related to precipitation is a common source of damage to cotton seedlings that frequently requires decisions about the necessity of replanting. The replanting decision boils down to evaluating whether the existing population of damaged seedlings has greater potential yield capacity than that of a new seedling population that results from replanting. While the details of each replant decision situation vary, a constant factor to evaluate is the reduced growing time of a healthy replanted population in comparison with the longer growing time of the existing damaged population.

The difference in growing season length is especially important in the Texas Southern High Plains where the length of growing season is characteristically shorter than most other cotton production areas. The average heat unit accumulation calculated as DD60s for the period 1965-1995 is 2260 with a range from 1831 (in 1976) to 2702 (in 1980) for the months May through October.

Information on early season physical crop damage and its relationship to potential yield is needed to make an informed decision about replanting. Barker et al. (1989) reported that cotton exposed to wind produced smaller plants with less leaf area. Sheltered cotton consistently produced more lint than unsheltered cotton at all planting dates and irrigation levels. In the Texas Southern High Plains, Keeling et al. (1995) found that irrigated cotton planted into terminated wheat which provided wind protection produced greater yields and net returns than conventional or minimum tillage without cover crops. After five years of continuously growing cotton under minimum tillage without cover crops, yields were lowest relative to other systems and deep breaking was needed to turn under sand.

High winds shortly after emergence can cause serious soil abrasive injury to cotton seedlings. Armbrust (1968) used a portable wind tunnel to expose young cotton seedlings to different amounts of sand abrasion by varying the wind velocity and number of exposures. Cotton seedlings 1 to 3 weeks old could only tolerate cumulative exposure to soil movement of 1.7 tons/acre or less without reducing yield. Longer and Oosterhuis (1995) in Arkansas treated nine-day-old cotton seedlings by removing either one or two cotyledons in combination with either removing or leaving true leaves intact in an irrigated field study. Plant height at harvest was not reduced by the removal of both cotyledons where true leaves remained and boll weight was not reduced compared to the control by the removal of one cotyledon.

We conducted simulated weather damage studies on cotton seedlings for the purpose of measuring the effect on growth rate recovery and final yield and to develop information for use in a decision support system for replanting.

Procedure

1996

The study was planted on the Texas Agricultural Experiment Station near Lubbock, TX. The soil is classified in the Olton series (fine, mixed, thermic Aridic Paleustoll). Liquid fertilizer formulated as 28-0-0 was chisled in every furrow on April 24 at the rate of 50 lbs. of N per acre. Paymaster HS 26 cotton was planted on May 20, 1996 into conventionally tilled beds with a John Deere 7300 MaxEmerge 2 Vacuumeter Planter. Beds were spaced 40-inches apart and oriented in a East-West direction. The planting rate was about 65,000 seeds per acre on all dates. A combination of Dual (1 pint per acre) and Caparol (1.75 pints per acre) herbicides were sprayed on the soil surface the day after planting for weed control. Emergence counts

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were taken in the center four rows of two randomly selected areas in the 8-row study.

A 2.5 inch irrigation was applied to every row on March 20 and on April 8 a 5.0 inch irrigation was applied to alternate furrows. After emergence drip irrigation laterals were placed on the surface of alternate furrows. The first in-season irrigation was applied on July 4.

On June 14, 1996, different amounts of leaf area were removed from seedlings to simulate physical vegetative damage imposed by weather. The treatments included removing: (a) no leaves removed - Control, (b) one cotyledon -C, (c) two cotyledons -2C, (d) all true leaves -TL, (e) one cotyledon and all true leaves -C-TL, and (f) two cotyledons and all true leaves -2C-TL. The simulated weather damage treatments were imposed on the middle six rows which were divided into four replications each 18 feet in length. Each simulated damage treatment was randomly assigned to one of the six rows in each replication. The experimental design was a randomized complete block with four replications. The amount of leaf area removed from the entire plot length of each simulated damage treatment on June 14 was measured and plants were harvested from 5 feet of single row lengths in the Control treatment. Biomass was sampled on June 28 and July 12 from 5 feet of single row lengths in all treatments.

Measurements of environmental data at 2 m above the soil surface included wet and dry bulb air temperatures, windspeed, and solar radiation. The first freezing temperature of 30°F occurred on October 22, 1996 and yields were determined by hand-harvesting 5 feet of a single row on November 20.

1997

The 1997 study was planted in a field located 3 miles east of the Agricultural Research Service headquarters at Lubbock, TX on May 16, 1997. The cotton variety Paymaster HS 26 was planted at the rate of 58,000 seeds/acre using a John Deere 7300 MaxEmerge 2 Vacuumeter Planter. The soil classification is Olton series (fine, mixed, thermic Aridic Paleustoll). Prior to planting 80 lbs of N per acre was injected into the beds and the herbicide Prowl was sprayed and incorporated on April 21. Row spacing was 40 inches with a North-South orientation.

Prior to planting drip irrigation laterals were buried 8-inches below the surface of each bed. Adequate rainfall before planting made irrigation unnecessary for seedling emergence. Each plot was 12 rows by 15 feet long. The experimental design was a randomized complete block. The simulated weather damage treatments were identical to those used in 1996. Treatments were applied to the middle six rows of each plot on June 10 and 11. Post treatment date biomass samples were taken on June 27 and July 11 by harvesting 15 randomly selected plants from each plot. The environmental measurements at the study site were similar to those recorded in 1996. The first freezing temperature of 30 °F occurred on October 26, 1997. Yields were determined by hand harvesting three 5 ft lengths from single rows in each plot.

Results

The amount of rainfall and irrigation from planting through the end of August was 620 mm in 1996 and 295 mm in 1997, Fig. 1. However, rainfall events on DOY 240 and DOY 241 account for 107 mm in 1996. Irrigation application in 1996 was automatically controlled by using the threshold canopy temperature procedure (Wanjura et al., 1992). Briefly, whenever the canopy temperature exceeded 28°C for 5.0 hours during one day and the time since last irrigation was at least 3-days, a 2.1 cm irrigation was applied. In 1997 the experiment was moved to another field where irrigation water was limited and it was not possible to utilize the threshold canopy temperature procedure to automate irrigation.

1996

When the treatments were imposed on June 14 the composition of total leaf area was 61% cotyledons and 39% true leaves in the -2C-TL and control samples, Table 1. The leaf area of cotyledons, removed in the four treatments that included the removal of one or two cotyledons, agreed more closely than the area of true leaves which were removed in three treatments. The higher variability for TL is likely due to the true leaves being very small and more difficult to uniformly remove by three different workers than whole cotyledons. Plant height in the control was 5.5 cm and the number of main stem nodes was 2.8 nodes. Plant sampling two and four weeks later showed that plant height, number of main stem nodes, and leaf area in the -C-TL and -2C-TL treatments were significantly reduced from the Control, Table 2. On July 12, plant height, number of main stem nodes and squares of treatments -C, -2C, and -TL were statistically similar to the control and were greater than treatments -C-TL and -2C-TL.

Plant survival in the -2C-TL treatment was 41% and 35%, respectively, on June 28 and July 12 compared with a survival of greater than 95% for the other treatments and the control.

Final lint yield was significantly reduced by the -2C-TL treatment, Table 3. Across all treatments there was a trend of decreasing yield with increased leaf area removed.

1997

Leaf area when the simulated damage was imposed on June 14 consisted of approximately 40% cotyledons and 60% true leaves in the -2C-TL and control treatments, Table 4. The total amount of leaf area removed from the -2C-TL treatment in the field and that removed from samples taken from the control and deleafed in the laboratory differed by

2%. Plants in the control treatment were 7.1 cm tall and had 2.3 main stem nodes.

On June 27, two weeks after imposing the simulated weather damage treatments plant height, vegetative dry weight, and leaf area were significantly lower in the -TL, -C-TL, and -2C-TL treatments compared with the control, Table 5. The number of main stem nodes was significantly reduced in all treatments compared to the control. One month after establishing the treatments, only the -TL and -2C-TL had shorter plants than the other treatments, and the -TL, -C-TL, and -2C-TL treatments had fewer main stem nodes, less vegetative dry weight, and less leaf area than the control.

Plant survival on July 9, one month after imposing the treatments, was 28 % in the -2C-TL treatment compared with the approximately 90% in the other simulated weather damage treatments including the Control.

Multiple range testing of yield means in 1997 segregated treatments into three overlapping groups, Table 3. The -2C-TL treatment yield was statistically lower than the Control yield. Across all treatments there was a trend of decreasing yield with increased leaf area removed in the young seedling stage.

Discussion

The amount of leaf area that remained on the seedlings immediately after imposing the treatments is plotted as post treatment residual leaf area in Fig. 2. The residual leaf area for each treatment was calculated as the difference between the leaf area of the Control minus the amount of cotyledon and true leaf area removed in each treatment. The control treatment plants had more leaf area when treatments were imposed in 1997 than in 1996. The difference in leaf area was primarily in the true leaves since the cotyledon area was similar in the two years, Tables 1 and 3. Two weeks after treatment, leaf area of all treatments was smaller in 1996 than in 1997. Four weeks after treatment the -C and -TL treatments in 1996 were larger than their corresponding treatments in 1997, the -C-TL, -2C-TL, and control treatments were similar, but the -2C treatment leaf area in 1996 remained smaller than in 1997. However, water supply differences did not affect vegetative development until after four weeks after treatment because leaf areas between years were more similar after four weeks than two weeks and the controls were equal, Tables 2 and 5. Between two and four weeks after treatment in 1997, the seedling suffered some leaf damage from thunder storms that generally slowed their growth compared to 1996.

The difference in yield response to the simulated weather damage treatments between 1996 and 1997 was primarily due to less water in 1997. Cumulative water received from planting as rainfall and irrigation was 59 mm and 72 mm when treatments were imposed, 153 mm and 95 mm two weeks after treatment, and 227 mm and 133 mm four weeks after treatment in 1996 and 1997, respectively. Water supply did not limit yield of any treatment in 1996 but restrained all treatment yields in 1997, Table 3. The differences in water supply affected the relative treatment effects. In 1996 with no water limitation only the -2C-TL treatment yielded significantly less than the Control. With the water limitation in 1997 yields of the Control, -C, and -C-TL were significantly higher than the -2C, -TL, and -2C-TL treatments.

When yield potential was reduced because of limited water, less physical damage to leaves could be tolerated. Relative post-treatment leaf area, showed little relationship to relative lint yield in 1997 but was strongly related in 1996, Fig. 3. The relative leaf areas and lint yields were calculated as a percentage of the Control treatment. These yield data suggest that the expected yield level must be considered when a replanting decision is made.

Summary

Simulated weather damage was inflicted on young cotton seedlings grown under full irrigation in 1996 and under limited irrigation in 1997. Cotton seedlings had leaf areas of 362 cm^2/m^2 and 592 cm^2/m^2 when treatments were imposed in 1996 and 1997, respectively. The difference in leaf area was due to greater true leaf area in 1997 than in 1996. Plant survival was significantly reduced by the most severe treatment, -2C-TL, in both years. Water supply differences between years did not affect vegetative development prior to four weeks after treatments were imposed. Lint yield was reduced by the most severe simulated weather damage treatment, -2C-TL, in both years.

References

Armburst, D. V. 1968. Windblown soil abrasive injury to cotton plants. Agron. J. 60:622-625.

Barker, G. L., J. L. Hatfield, and D. F. Wanjura. 1989. Influence of wind on cotton growth and yield. Trans. ASAE 32(1):97-103.

Keeling, W. K., W. M. Lyle, A. B. Onken, K. Hake, J. F. Farris, and J. G. Smith. 1995. Evaluation of irrigated and dryland cropping systems for the Texas Southern High Plains. In: M. R. McClelland, T. D. Valco, and R. E. Frans (eds) Conservation-tillage systems for cotton. pp. 109-112. Univ. Ark. Agric. Exp. Stn. Spec. Rep. 169.

Longer, D. E. and D. M. Oosterhuis. 1995. Regrowth of defoliated cotton seedlings in laboratory and field environments. In: D. M. Oosterhuis (ed), Proceedings of the 1995 cotton research meeting and 1995 summaries of cotton research progress. pp. 86-89. Ark. Agric. Exp. Stn. Spec. Rep. 172.

Wanjura, D. F., D. R. Upchurch, and J. R. Mahan. 1992. Automated irrigation based on threshold canopy temperature. Trans. ASAE 35: 1411-1417.

Table 1. Amount of leaf area removed by treatments simulating plant weather damage on June 14, 1996.

Treatment	Leaf area removed, cm^2/m^2[*]		
	Cotyledons	True leaves	Total
-C	96 b[**]	0 c	96
-2C	193 a	0 c	193
-TL	0 c	179 a	179
-C-TL	95 b	155 ab	246
-2C-TL	187 a	119 b	306
Control[***]	0	0	0

[*]The leaves for the five simulated damage treatments were removed from 18 feet of a single row and those for the Control were harvested from 5 feet and converted to an 18 foot length. The units for leaf area removed are cm^2 of leaves per m^2 of ground area.
[**]Numbers in the same column for the same harvest date followed by a common letter are statistically the same at the 0.05 probability level according to Duncan's New Multiple Range Test.
[***]The Control treatment had cotyledon, true leaf, and total leaf areas of 220, 140, and 362 cm^2/m^2, respectively.

Table 2. Plant development of simulated weather damage treatments and the control treatment on two dates prior to first bloom, 1996.[*]

Treat-ment	Plant Height, cm	Nodes No.	Squares No.	Vegetative Dry Wt., g	Leaf Area, cm^2/m^2
			June 28		
Control	11.7 a[**]	6.6 a	0.66 a	19.7 a	1,356 a
-C	10.4 b	6.3 ab	0.57 ab	5.9 ab	973 b
-2C	9.3 c	5.9 bc	0.38 b	12.2 bc	802 bc
-TL	9.5 bc	6.3 ab	0.03 c	11.1 bc	727 bc
-C-TL	7.9 d	5.5 c	0.06 c	7.5 c	418 cd
-2C-TL	6.4 e	4.8 d	0.00 c	1.9 d	53 d
			July 12		
Control	21.2 a	10.0 a	5.9 a	65.9 a	4,658 a
-C	22.8 a	10.3 a	6.1 a	68.1 a	4,905 a
-2C	21.5 a	9.9 a	5.6 ab	61.4 a	4,484 a
-TL	20.8 a	10.4 a	4.5 b	56.3 ab	4,117 a
-C-TL	15.1 b	8.8 b	2.5 c	33.5 b	2,873 a
-2C-TL	10.0 c	7.7 c	0.4 d	4.7 c	278 b

[*]Sample size is 5 feet of a single row.
[**]Numbers in the same column for the same harvest date followed by a common letter are statistically the same at the 0.05 probability level according to Duncan's New Multiple Range Test.

Table 3. Lint yields for simulated weather damage treatments and a control treatment, 1996-1997.

Treatment	1996	1997
	--------------Lbs./Acre-----------	
Control	1129 a[*]	577 a
-C	1034 ab	589 a
-2C	928 ab	457 b
-TL	932 ab	464 b
-C-TL	828 ab	571 a
-2C-TL	329 c	426 b

[*]Numbers in the same column for the same harvest date followed by a common letter are statistically the same at the 0.05 level according to Duncan's New Multiple Range Test.

Table 4. Amount of leaf area removed by treatments simulating plant weather damage on June 10, 1997.

Treatment	Leaf Area Removed, cm^2/m^2[*]		
	Cotyledons	True Leaves	Total
-C	101	0	101 e[***]
-2C	212	0	212 d
-TL	0	350[**]	350 c
-C-TL	101[**]	350[**]	423 b
-2C-TL	212[**]	350[**]	577 a
Control[****]	0	0	0

[*]Leaf area for the five simulated damage treatments was removed from 15 feet of a single row and those for the Control were harvested from 5 feet and adjusted to a 15 foot length.
[**]These values are the measured values from either treatments -C, -2C, or -TL. Total leaf area was measured in -C-TL, -2C-TL, and the Control treatment.
[***]Total leaf area values followed by a common letter are statistically the same at the 0.05 probability level according to Duncan's New Multiple Range Test.
[****]The Control treatment had cotyledon, true leaf, and total leaf areas of 212, 350, and 592 cm^2/m^2, respectively.

Table 5. Plant development of simulated weather damage treatments and a control treatment on two dates prior to first bloom, 1997[*].

Treatment	Plant Height, cm	Nodes No.	Squares No.	Vegetative Dry Wt., g	Leaf Area, cm^2/m^2
	June 27[**]				
Control	16.2 a[**]	7.7 a	0.0	20.7 a	1,438 a
-C	14.4 b	6.1 c	0.0	16.4 ab	1,160 bc
-2C	14.2 b	5.3 d	0.0	14.4 bc	1,231 b
-TL	12.7 b	7.2 b	0.0	11.4 c	979 c
-C-TL	13.1 b	7.0 b	0.0	10.0 c	791 d
-2C-TL	8.0 c	5.2 d	0.0	2.2 d	36 e
	July 11[**]				
Control	30.7 a	10.5 a	6.6 a	90.0 a	4,657 ab
-C	26.9 ab	9.7 b	5.5 b	73.6 b	3,993 bc
-2C	28.9 ab	10.6 a	7.2 a	97.5 a	5,171 a
-TL	24.6 b	9.4 b	4.6 b	61.4 bc	3,211 dc
-C-TL	26.7 ab	9.1 b	3.3 c	56.9 c	2,973 d
-2C-TL	9.7 c	9.1 ab	0.4 d	4.8 d	215 e

[*]Sample size is 15 plants per plot. Based on population counts 15 plants represent 1.16 m^2 of area on June 27 and 1.29 m^2 on July 11.

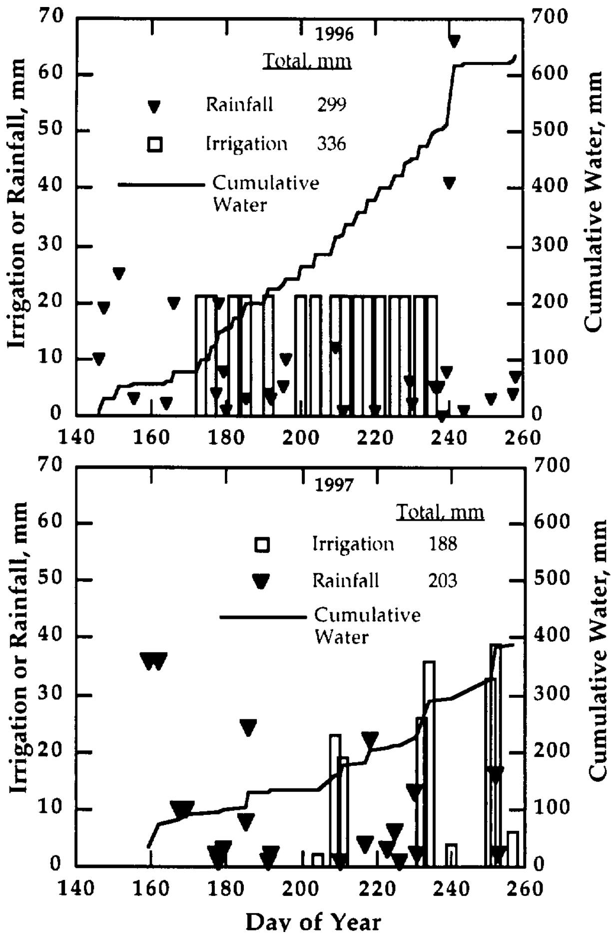

Figure 1. Distribution of rainfall and irrigation events in 1996 and 1997.

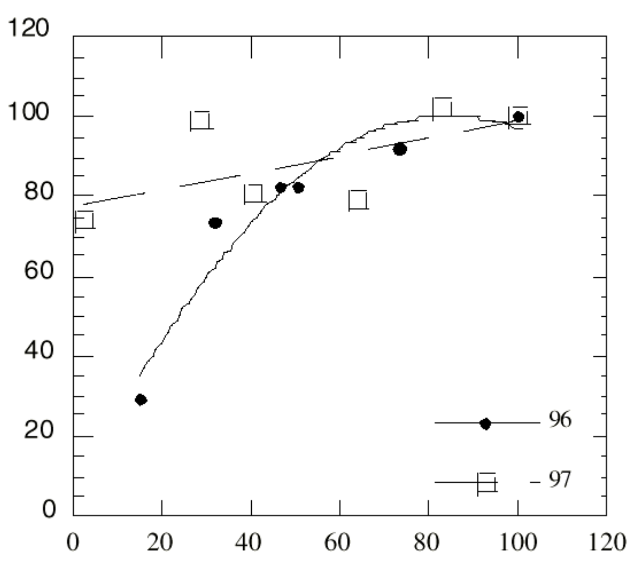

Figure 3. Relationship of relative post treatment leaf area and relative lint yield for six simulated weather damage treatments in 1996 and 1997.

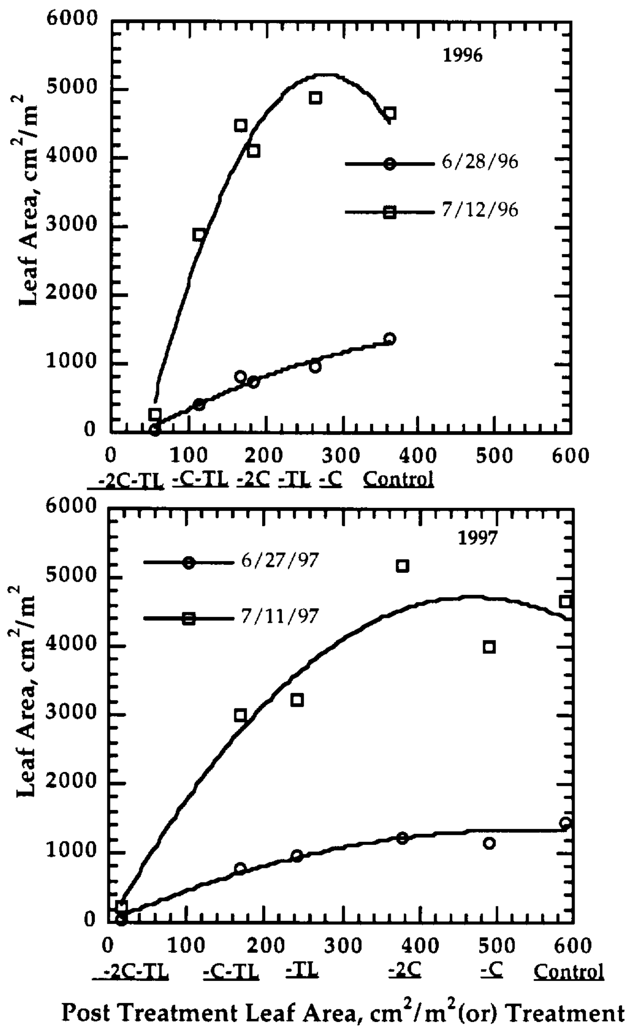

Figure 2. Relationship of post treatment leaf area with leaf area two and four weeks later for six simulated weather damage treatments in 1996 and 1997.