Chapter 7

UNIFORM HARVEST-AID PERFORMANCE AND LINT QUALITY EVALUATION

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INTRODUCTION

Today, successful cotton production largely is dependent on the use of harvest-aid products designed to defoliate plant leaves, accelerate boll opening, enhance seed cotton drying in the field, and, in some cases, desiccate green plant material. The application of chemical harvest-aid materials also can have varying effects on quality of the fiber.

FIBER QUALITY

Proper application of harvest-aid materials is important for preserving fiber quality by facilitating timely harvest and reducing plant trash created by mechanical harvesting procedures. Conversely, harvest aids can affect fiber quality adversely if applied at the wrong developmental stage of cotton (Snipes and Baskin, 1994).

The indeterminate growth habit of the cotton plant results in longer periods of exposure for lower, open bolls, relative to upper, less-mature bolls that remain unopened at optimum physiological maturity. Certain types of harvest-aid materials are used to facilitate the opening of these younger, unopened bolls, in order to achieve an earlier, once-over harvest.

Application of harvest-aid materials is a chemical termination of the crop to facilitate harvest and to preserve optimum fiber quality. Long-term exposure to weather can reduce lint yield and lead to degradation of fiber quality (Ray and Minton, 1973). Thus, chemical termination of the crop is a compromise between further gains in yield and the risk of weather-related losses from extended periods of exposure of more-mature bolls.

Harvest aids facilitate timely harvesting, reduce seed cotton moisture, and improve storage conditions after harvest (Wooten and Montgomery, 1960), and they improve lint grades (Parker and Wooten, 1964; Whitwell and Walker, 1985).

Harvest aids also have been shown to reduce yield (Barker *et al.,* 1976; Williford, 1992). In two years of a four-year study, defoliation reduced cotton yield when compared to non-defoliated cotton. However, the lint grade index was increased in two of the four years. Grade loss was associated with green plant material. On the average, one out of five bales in the non-defoliated plots was reduced one grade because of green chlorophyll stains (Williford, 1992).

TIMING

Williford (1992) also reported that the use of ethephon to accelerate boll opening allowed for an earlier harvest, but that, when applied at or prior to 60 percent open bolls, ethephon resulted in lint yield and quality loss. Lint grade reduction was associated with the loss of lint color and, to a lesser degree, additional trash. Williford concluded that twice-over harvest appears to be the best harvest system with respect to yield and grade, but the economic implications of twice-over harvest should be considered in the management decision.

In another study, it was shown that application of harvest-aid materials, with or without ethephon, reduced yields and lowered micronaire if applied at 20 percent or 40 percent open bolls (Snipes and Baskin, 1994). Once cotton had reached the 60 percent or 80 percent open-boll stage, there were no adverse affects to yield or fiber quality regardless of the type of harvest-aid material used.

An earlier study reported that the use of combination treatments, usually including ethephon as a component, provided better defoliation than when either component was used alone (Snipes and Cathey, 1992). Thus, ethephon is a plant growth regulator frequently used in harvest-aid strategies for cotton. When applied at the appropriate rate to cotton that has a sufficient load of mature, unopened bolls, ethephon accelerates boll opening and enhances defoliation, while also removing immature fruit structures (Hope and Needham, 1987; Snipes and Cathey, 1992). When applied in combination with another harvest-aid material, ethephon allows for the possibility of a once-over harvest with spindle pickers. However, defoliation enhancement with ethephon may affect lint quality by reducing micronaire, especially if applications are made prior to maximum physiological crop maturity.

It stands to reason that harvest aids should be applied only when all plant processes are complete. However, many times other factors come into play in the application of harvest-aid treatments. The condition of the plant prior to application and environmental factors during and after application play important roles in the efficacy of a harvest-aid product or mixture of products (Supak, 1995; Snipes and Baskin, 1994).

Studies conducted in the Mississippi Delta showed that harvest aids should not be applied until at least 60 percent of the cotton has reached the open-boll stage (Snipes and Baskin, 1994). Another study conducted in Alabama also indicated that terminating the crop prior to 60 percent open bolls may decrease yield and adversely affect fiber quality (Whitwell *et al.*, 1987).

Snipes and Baskin (1994) confirmed yield losses when harvest-aid materials (tribufos, thidiazuron, ethephon, and a combination of tribufos or thidiazuron plus ethephon) were applied at 20 percent and 40 percent open bolls. They also showed that micronaire was decreased when harvest aids were used prior to 40 percent open bolls. However, an increase in fiber strength and length was observed when harvest aids were used at 20 percent open bolls. This was attributed to the physiological abscission of immature bolls, leaving a higher percentage of older, more-mature bolls for harvest.

The study concluded that treatments should not be applied prior to 60 percent open bolls in order to safeguard against potential losses in yield and undesirable changes in fiber quality. Yield losses and quality reductions occurred because of improper timing, irrespective of harvest aid used. Increases in yield in the non-defoliated control plots in these studies indicated a higher trash content in the harvested sample and the additional yield gained by approximately two weeks of additional growth, relative to the defoliated plots. These slight increases occur when small areas are harvested in a timely fashion and risk of weathering loss is minimal, both of which conditions are difficult to achieve on a commercial scale.

Field studies were conducted in Alabama to evaluate early and normal application of several harvest aids: ethephon, tribufos, and thidiazuron (Whitwell and Walker, 1985). Early application was made when bolls were 30 percent to 50 percent open; normal application was delayed until bolls were 65 percent to 75 percent open. Early application of ethephon increased the percent of lint picked from the first harvest and reduced total yield in only one year out of three.

In this study, fiber quality was influenced more by application time than by chemical treatment. Fiber length, uniformity, strength, and elongation were increased with early application of harvest aids in one year, while they showed no effect the other years. This study concluded that, during the years of evaluation, early application of harvest aids had minimal negative effects while increasing percent of yield from first harvest.

Thibodeaux *et al.* (1993) showed that, when ethephon was applied to cotton prematurely (10 percent open bolls), there was a decrease in fiber maturity or fiber wall development for the top portion of the cotton plant, with a corresponding increase in neps (hopelessly entangled masses of fibers). However, this study also indicated that there was no significant reduction in fiber strength or length.

Stripper harvest of cotton requires defoliating leaves with some desiccation of the cotton plant. Evaluations of harvest-aid materials by Supak *et al.* (1994) have shown their effectiveness as defoliants and desiccants in the stripper cotton-growing areas.

Although some desiccation of the plant is necessary, it is not desirable to kill and completely dry the cotton plant prior to harvest. If the plant is completely desiccated, harvest will remove excessive amounts of foreign matter, such as leaves, stems, and even slivers of bark. Subsequent routine cleaning in the gin process may not adequately remove this foreign matter. Excess lint trash requires additional non-routine cleaning procedures that may result in lower fiber quality. However, harvest aids should sufficiently dry the seed cotton and foreign matter to permit storage prior to ginning without loss of fiber quality.

A study on the Texas High Plains evaluated four harvest-aid combinations – including defoliants, desiccants, and boll openers. The results from treated plots were compared to results obtained from harvesting one treatment without chemicals, after a freeze (Brashears *et al.,* 1997). The treatment that received no harvest-aid material had higher levels of sticks and fine trash and lower fiber qualities than the treatments that included harvest-aid materials. This was attributed to the extended exposure of the untreated cotton to weather. This study indicated that early stripper harvest using harvest-aid materials gave consistently better fiber quality, as opposed to waiting to harvest the cotton after a killing freeze.

BELTWIDE PROJECT

In 1992, a Beltwide project was designed to evaluate the influence of harvest-aid materials on fiber quality. The overall objective of the project was to develop effective, practical harvest-aid recommendations that would contribute to harvest efficiency and high-quality fiber, specifically by evaluating performance of standard defoliation treatments on a uniform basis and relating this performance to biotic and environmental factors. The following is a discussion of the fiber quality portion of the five-year project.

MATERIALS AND METHODS

The specific details of this experiment are described in previous manuscripts (Anonymous, 1999). In these trials, seven core harvest-aid treatments (Table 1) were applied at 16 test sites located in Alabama, Arkansas, California, Florida, Georgia, Louisiana, Mississippi, Missouri, North and South Carolina, Oklahoma, Tennessee, and four sites in Texas. These locations were combined into four regions, Southeast (Alabama, Georgia, North Carolina, South Carolina, and Florida), Midsouth (Arkansas, Louisiana, Missouri, Mississippi, and Tennessee), Southwest (Texas and Oklahoma), and Far West (California only).

Table 1. Core harvest-aid treatments used in the Uniform Harvest-Aid Performance and Lint Quality Evaluation (1992-1996).

Core Treatment	Application Rate (per acre)
Untreated check	
Folex®/Def® (tribufos)	1.5 pt
Dropp® (thidiazuron)	0.2 lb of product
Harvade® (dimethipin) + COC[1]	8 oz of product 1 pt
Harvade + Prep™ (ethephon) + COC[1]	6.5 oz 1.33 pt 1 pt
Folex/Def + Prep	0.75 pt 1.33 pt
Dropp + Prep	0.1 lb of product 1.33 pt

Source: Anonymous, 1999.
[1] Crop Oil Concentrate.

The Beltwide project evaluated seven "core" treatments and a number of "regional standards" in a multiyear study conducted at multiple locations in four major production regions of the Cotton Belt. Standard agronomic practices for optimum cotton productivity were used at each of the test sites. Pre-selected cotton varieties were used at each test site in the four regional locations. Harvest-aid chemicals were applied at about 60 percent open bolls. Standardized evaluation data were collected and recorded by each of the investigators at 7 and 14 days after treatment (DAT). Plots were mechanically harvested at approximately 14 DAT. The three stripper sites (two in Texas and one in Oklahoma) were desiccated with paraquat prior to harvest.

Two groups of seed cotton samples were collected at each site. One group of small samples (approximately 2.5 pounds) was collected by plot for all treatments. These small samples were shipped to the Texas A&M Research and Extension Center in Lubbock for ginning. Each year all samples were ginned at the same relative time period. The gin was equipped with an inclined cleaner, extractor feeder, 10-saw gin, and single stage of lint cleaning.

Lint data collected from ginned samples were subjected to HVI (High-Volume Instrumentation) analysis, which included micronaire, strength, length, percent trash, reflectance (Rd), yellowness (+b), length uniformity index (LUI), short fiber content (SFC), and leaf grade. The 1994 to 1996 data also were analyzed using the Uster AFIS (Advanced Fiber Information System) instrument for all samples from selected locations. These included five spindle-picked locations (Louisiana, Mississippi, Georgia, North Carolina, and California) and two stripper-harvested locations (Lubbock, Texas, and Oklahoma). Lint data collected were nep counts, visible foreign matter (VFM), upper quartile length (UQL), and SFC.

A second set of samples was collected for each core treatment. These large samples were approximately 50 pounds and represented a composite of all plots within a treatment. From 1992 through 1994, these samples were sent to the USDA, ARS Cotton Ginning Laboratory, in Stoneville, Mississippi, for ginning using the micro gin and one lint cleaner. The lint was sent to the USDA, ARS Cotton Quality Research Station, at Clemson University, where the samples were spun into yarn and knitted into fabric. The fabric was dyed and white speck counts were made. White specks are defined as entanglements of very immature fiber that have different reflective characteristics from those of surrounding fiber.

A preliminary analysis of variance of the data combined over year and location indicated that treatment interacted with year and location in a similar manner.[1] Therefore, in a subsequent analysis, year and location were considered environment and were used as replications for comparing treatments. Differences in treatment means were declared significant at the five percent level of probability and were separated by Least Significant Difference (LSD).

In a separate analysis, percent defoliation at 14 DAT was used as a continuous effect (X) to describe the treatment effect on selected fiber quality measurements (Y). Slopes were estimated and tested for significance ($p<0.05$) to evaluate the overall effect of percent defoliation on fiber quality. This report includes five years of lint-quality data collected from the seven core treatments. However, not all test locations had five years of data. Because of the large number of samples (about 2,100), relatively small measurement differences were statistically significant.

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[1]Data were analyzed with the assistance of Debbie L. Boykin, Statistician, USDA, ARS, in Stoneville, Mississippi.

RESULTS AND DISCUSSION

Percent defoliation – At 7 DAT and 14 DAT, Folex® at 0.75 pint per acre plus Prep™ at 1.33 pints per acre had the highest percent defoliation and a corresponding low trash content and high reflectance (Table 2). As expected, the percentage of trash content from the untreated check was slightly higher than for all other treatments, with the Folex + Prep treatment having the lowest percentage of trash.

It is important to note that percent defoliation is only one component in overall evaluation of a harvest aid. Folex + Prep provided a high level of defoliation, but the treatment has been shown to lack regrowth-inhibition properties that may be desirable in many cases (Legé *et al.,* 1997).

Table 2. Influence of harvest-aid treatments on percent defoliation and selected HVI lint quality measurements at all test sites (1992-1996).[1]

TREATMENT DESCRIPTION	% DEFOLIATION 7 DAT	14 DAT	TRASH (% area)	MICRONAIRE	Color Rd[2]	+b[3]	Color Grade[4]
1. Untreated check	23.2 d	36.5 e	0.40 b	4.43 c	74.2 b	8.58 b	41-3
2. Folex® @ 1.5 pt	59.7 b	72.7 bcd	0.37 ab	4.39 b	74.9 a	8.35 a	31-2
3. Dropp® @ 0.2 lb	51.2 c	67.8 d	0.37 ab	4.40 b	74.9 a	8.38 a	31-2
4. Harvade® @ 8 oz + Agri-Dex® @ 1 pt	56.2 c	69.5 cd	0.39 ab	4.37 b	74.9 a	8.34 a	31-2
5. Harvade @ 8 oz + Prep™ @ 1.33 pt + Agri-Dex @ 1 pt	63.1 b	74.3 bc	0.38 ab	4.31 a	74.8 a	8.39 a	31-2
6. Folex @ 0.75 pt + Prep @ 1.33 pt	69.0 a	80.7 a	0.35 a	4.31 a	75.0 a	8.37 a	31-2
7. Dropp @ 0.1 lb + Prep @ 1.33 pt	63.3 b	77.2 ab	0.37 ab	4.31 a	74.9 a	8.41 a	31-2

Source: Anonymous, 1999.

[1] Means within columns followed by the same letter are not statistically different. Location and year had an equal impact on error structure, thus were considered environment and used as replications for comparing treatments.

[2] Reflectance.

[3] Yellowness.

[4] All color grades are based on the Nickerson Hunter Color/Grade Translator.

Color trash – The color measurements, Rd and +b, for the untreated check, had lower reflectance and higher yellowness when compared to all harvest-aid treatments (Table 2). However, no significant differences in reflectance or yellowness were noted among harvest-aid treatments. Color grades, based on the Nickerson Hunter Color/Grade Translator, were 31 for all treatments, while the untreated check had a color grade of 41. Other HVI measurements showed no significant differences among treatments.

Micronaire – Treatments containing Prep had lower micronaire values when compared to the untreated control or treatments without Prep (Table 2). Differences in levels of defoliation for each treatment were reflected by these micronaire values. As percent defoliation increased, micronaire tended to decrease. Because the removal of leaves typically stops all plant processes, the untreated check had additional developmental time relative to the treated plots, resulting in higher micronaire values. Lower percent defoliation in treatments without Prep resulted in partial continued fiber development of the crop and slightly higher micronaire values than treatments with higher percent defoliation. Harvest-aid treatment did not reduce micronaire sufficiently to produce unacceptable fiber.

Average white speck counts showed little variation among harvest-aid treatments (Table 3). There was considerable variation between years or production seasons, but no trend to indicate that any of the defoliation treatments increased white speck counts. This indicated that white specks largely were a product of the conditions encountered during the growing season.

Fiber quality measurements – A more sophisticated analysis of selected lint samples using the AFIS instrumentation is shown in Table 4. Nep counts, VFM, and UQL were not affected by any treatment evaluated. There were no significant differences in SFC measurements among any treatments evaluated.

To determine if the efficacy of the various harvest-aid methods affected lint quality, a slope comparison using linear regression analysis for micronaire, white speck, neps, and short fiber content versus percent defoliation at 14 DAT was performed (Table 5). Slopes differing from zero, where a zero slope indicates no effect, defined the impact of percent defoliation on the chosen quality parameter measured. The negative slope of the linear regression lines indicated that, irrespective of the harvest aid used, as percent defoliation increased, micronaire was reduced in both spindle-harvested and stripper-harvested cotton. Therefore, when defoliation is more complete, subsequent or continued development of the cotton fiber is diminished.

Table 3. Number of white specks[1] observed in 40 square inches of dyed jersey knit fabric over a three-year period.

TREATMENT DESCRIPTION	1992 (n=12)	1993 (n=16)	1994 (n=18)
1. Untreated check	293	136	88
2. Folex® @ 1.5 pt	300	132	83
3. Dropp® @ 0.2 lb	261	128	82
4. Harvade® @ 8 oz + Agri-Dex® @ 1 pt	294	136	91
5. Harvade @ 8 oz + Prep™ @ 1.33 pt + Agri-Dex @ 1 pt	269	123	86
6. Folex @ 0.75 pt + Prep @ 1.33 pt	289	131	85
7. Dropp @ 0.1 lb + Prep @ 1.33 pt	278	119	74

Source: Anonymous, 1999.
[1] White specks are entanglements of very immature fiber that have different reflective characteristics from those of surrounding fibers.

It was concluded that changes in micronaire occurred because of the process of defoliation rather than the effect of any specific harvest-aid material, which agreed with earlier findings that timing also plays a role (Snipes and Baskin, 1994). White speck count did not change with increased defoliation values for either harvest method. Thus, any changes in micronaire did not result in poor fabric quality, as measured by white speck count.

Based on AFIS measurements, neither neps for spindle-harvested cotton nor short fiber content for stripper-harvested cotton was influenced by an increased level of defoliation (Table 5). Conversely, neps in stripper-harvested cotton and short fiber content in spindle-harvested cotton increased as level of defoliation increased. However, departures from zero slope were relatively small and indicated these changes were well within acceptable limits.

Table 4. Influence of harvest-aid treatments on selected AFIS[1] fiber quality measurements from selected 1994-1996 test locations.[2]

TREATMENT DESCRIPTION	NEP[3] (ct)	VFM[4] (%)	SFC[5] (%)	UQL[6] (in)
1. Untreated check	182.0 ab	1.60 ab	9.59 a	1.152 ab
2. Folex® @ 1.5 pt	184.6 a	1.49 b	9.76 a	1.147 ab
3. Dropp® @ 0.2 lb	175.1 b	1.52 ab	9.59 a	1.157 b
4. Harvade® @ 8 oz + Agri-Dex® @ 1 pt	186.9 a	1.66 a	9.62 a	1.145 ab
5. Harvade @ 8 oz + Prep™ @ 1.33 pt + Agri-Dex @ 1 pt	181.5 ab	1.55 ab	9.75 a	1.145 ab
6. Folex @ 0.75 pt + Prep @ 1.33 pt	189.2 a	1.58 ab	9.86 a	1.150 ab
7. Dropp @ 0.1 lb + Prep @ 1.33 pt	184.8 a	1.64 ab	9.72 a	1.131 a

Source: Anonymous, 1999.
[1] Advanced Fiber Information System.
[2] Means within columns followed by the same letter are not different at the five percent level of probability.
[3] Neps are hopelessly entangled masses of fibers.
[4] Visible Foreign Matter.
[5] Short Fiber Content by weight.
[6] Upper Quartile Length.

Table 5. Linear regression comparisons of selected quality measurements and harvest methods vs. percent defoliation at 14 DAT.[1]

Quality Measurement	y-intercept	Slope	Pr>T[2]
1992-1994 Micronaire and white speck quality measurements			
Micronaire (spindle)	4.48	-0.0015	0.0001
Micronaire (stripper)	4.52	-0.003	0.0002
White speck (spindle)	96.72	-0.022	0.8528 (ns[3])
White speck (stripper)	93.33	0.27	0.5599 (ns[3])
1994-1996 AFIS[4] quality measurements			
Neps[5] (spindle)	169.88	-0.0599	0.4705 (ns[3])
Neps[5] (stripper)	81.97	1.6628	0.0053
SFC[6] (spindle)	9.58	0.0052	0.0289
SFC[6] (stripper)	8.84	0.0023	0.7613 (ns[3])

Source: Anonymous, 1999.
[1] Percent defoliation at 14 DAT (x) is used to describe treatment effect on fiber quality (y) and tested for significance to evaluate the overall effect.
[2] Probability that the dependent variable is greater than the test value (T).
[3] ns = not significant at the 0.05 percent level.
[4] Advanced Fiber Information System.
[5] Neps are hopelessly entangled masses of fibers.
[6] Short Fiber Content by weight.

SUMMARY

This study revealed few differences among harvest-aid treatments and lint quality when recommended production practices were followed. Harvest aids reduced trash, reduced micronaire slightly, and improved color. Harvest aids did not appear to increase white specks or neps, and did not reduce strength, length, or uniformity. Even though differences in defoliation efficacy were measured, ginning and lint cleaning tended to normalize differences in trash content. More important, it was shown that proper application of harvest-aid materials served as an acceptable means of crop termination while capturing and preserving fiber quality.

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