PREPARING FOR HARVEST WITHOUT CHEMICALS

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Abstract

New environmental laws may someday restrict defoliant chemical application. To prepare for this possible challenge experimental thermal defoliators were operated in California, New Mexico and Texas from 2001 through 2007. This paper summarizes findings from extensive trials in a variety of field conditions and cultivars. Physiological studies showed the efficacy of thermal defoliation and its impact on yield and harvest timing. Fiber quality studies indicated no damage to lint value. Entomological studies demonstrated reduced late season pest populations. Harvest is possible within hours of treatment. Fuel costs are similar to chemical costs.

Introduction

Cotton defoliation became widely practiced with harvest mechanization (Funk, 2004). Defoliation makes once-over picking possible and greatly reduces field problems caused by plant sap gumming up picker spindles. Defoliation helps growers to pick sooner, thus avoiding late season insect and weather damage and making better use of harvest equipment and labor. Defoliation also helps growers to realize improved leaf grades. Unfortunately, the chemicals used to accomplish necessary harvest preparation may someday be targeted by citizens concerned about the impact of agriculture on the environment. To prepare for this possibility, the USDA-Agricultural Research Service-Southwestern Cotton Ginning Research Laboratory in Mesilla Park, NM began to investigate alternative methods for crop termination. Hot air was found to be the best tool to desiccate cotton leaves. Thermal defoliation results in leaf kill more than in leaf drop, but makes harvest possible within 24 hours of treatment (Showler et al., 2006).

Field trials conducted from 2001 through 2007 at multiple locations in California, New Mexico and Texas all used both heat and conventional defoliant chemical treatments to prepare cotton for harvest. These multiple trials answer most of the basic questions about thermal defoliation: does it work; how much fuel is needed, how long until the crop is ready for harvest; what impact does thermal treatment have on yield; do any fiber properties change; and what becomes of insect pests? This paper summarizes findings from extensive trials in a variety of field conditions and cultivars. Results confirmed work done in the 1960's at Oklahoma State University (Batchelder et al., 1971).

Materials and Methods

Three thermal defoliation machines were constructed. A one-row experimental unit was tested in 2001 and 2002 (Funk et al., 2002). A two-row prototype unit was used from 2003-2006 (Funk, 2007). A six-row commercial unit was completed late in 2007 and treated one field (82 acres). The commercial unit was 52 feet long overall (Figure 1). The commercial unit had six fan/burner sections each two rows by 15 feet long. They were arranged on the frame to provide thirty feet of coverage to six 30 inch rows. Propane self-vaporizing grain drying fan/burner assemblies blew hot air into each row from alternate sides. Hydraulic motors turned their fans. A 330 HP diesel engine turned five hydraulic pumps, supplying power for propulsion, fan motors and auxiliaries.

Figure 1. Commercial thermal defoliator completed late 2007.

Figure 2 is a map of field locations showing the year and location where experiments took place. Table 1 lists the year, location and objectives of each experiment. For the 2003 experiments in California and the 2006 experiments in Weslaco,TX, insecticides were included with the mix of desiccant and defoliant chemicals sprayed on the control plots, to measure their potential to reduce lint stickiness from late-season sucking insects. Otherwise all experiments were direct comparisons between thermal defoliation and treatment with the chemical defoliation tank mix most commonly used in the area where the trial took place. Some of the plots in Lubbock in 2004 were treated with a boll opening chemical (Ethephon) before thermal defoliation. Otherwise, all thermal treatments were chemical-free.

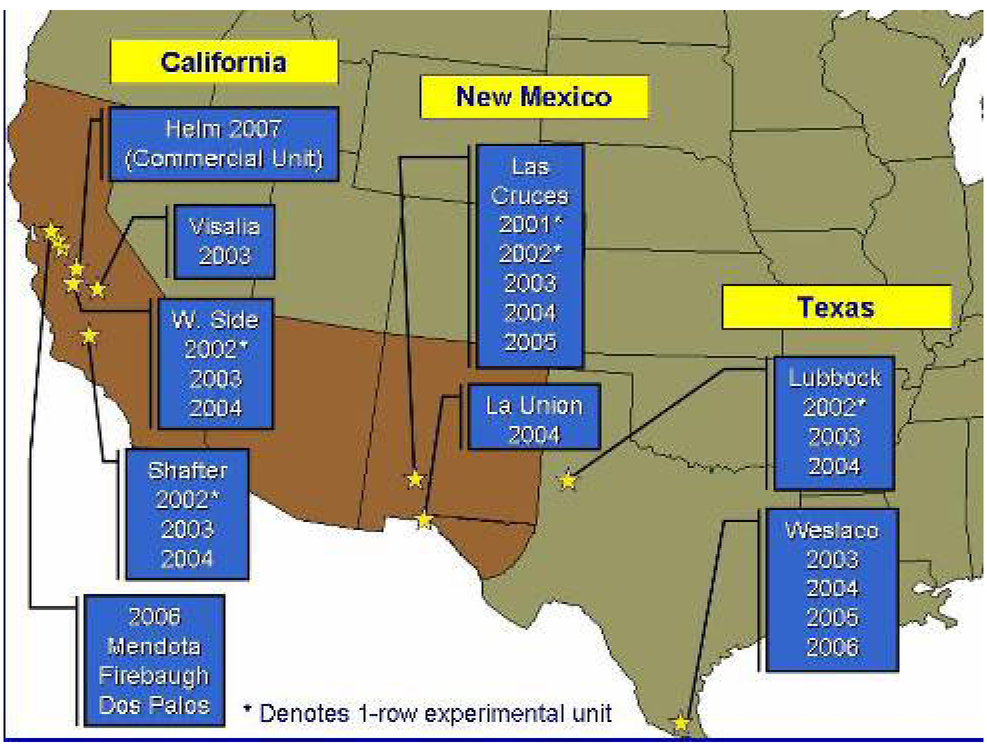

Figure 2. Field locations and dates for thermal defoliation trials.

Major Findings

Ginning Results (Funk et al., 2003)

Early work with the experimental (one row) thermal defoliator examined desiccation and defoliation responses for low, <10 gal/acre, medium, 10-15 gal/acre, and high, >15 gal/acre propane use at Las Cruces. Comparisons were also made between thermal and chemical defoliation in stripper harvested cotton at Lubbock. An interesting finding was that though the leaf material in seedcotton was higher with thermal defoliation, leaf material in baled lint was less. It appeared easy for gin cleaning machinery to remove dry, crumbly thermally desiccated leaf matter.

Fiber and Yarn Properties (Funk et al., 2004a)

Research with the new prototype (two-row) thermal defoliator confirmed significantly better leaf and color grades and loan values when using more than 10 gal/ac propane for heat treatments compared to conventional chemical defoliation. Other fiber quality properties measured by the USDA-AMS Classing Office High Volume Instrument (HVI) were unchanged. The USDA-ARS-Cotton Quality Research Unit at Clemson found that there were fewer thicks as well as a slight decrease in irregularities with yarn made from thermally defoliated cotton. All other spinning and yarn quality measures were not statistically different.

Table 1. Year, location and objective of each experiment.

Year	Location	Objective
2001	Las Cruces, New Mexico	Technical feasibility and fiber quality impact
		Range of effective temperature and dwell time
2002	Las Cruces, New Mexico	Optimal temperature and dwell time
		Chile pepper feasibility
	Shafter, California	Field demonstration
	Five Points, California	Field demonstration
2003	Weslaco, Texas	Test new prototype unit
	Las Cruces, New Mexico	Physiology in three varieties
		Fiber quality
		Chile pepper response physiology
	Shafter, California	Participate in beltwide insecticide study
	Visalia, California	Participate in beltwide insecticide study
	Five Points, California	Participate in beltwide insecticide study
	Lubbock, Texas	Test in stripper cotton varieties
		Ginning and fiber quality impact
2004	Weslaco, Texas	Physiology of response
		Remote sensing feasibility
	Shafter, California	Harvest timing study
	Five Points, California	Harvest timing study
	Las Cruces, New Mexico	Harvest timing study
		Varietal trials
	La Union, New Mexico	Difference in organic Pima
		Difference in organic upland
	Lubbock, Texas	Harvest timing study
		Effect with ethephon (boll opener)
2005	Weslaco, Texas	Physiology of response (year 2)
		Remote sensing feasibility (year 2)
	Las Cruces, New Mexico	Insect mortality
		Stickiness mitigation
		Harvest timing study
2006	Mendota, California	Effectiveness in high-quality organic cotton
	Firebaugh, California	Effectiveness in field inaccessible by air
	Dos Palos, California	Effectiveness in urban area
	Weslaco, Texas	Pesticide replacement
2007	Helm, California	Field trials for new Commercial Unit

Impact on Fiber Value and Yarn Quality (Funk et al., 2004b)

Although no differences were measured in leaf grade, color grades were still significantly better with thermally defoliated cotton compared to chemically defoliated cotton, all other classing office measures of fiber value remaining the same for both treatments. Advanced Fiber Information System measures of fiber quality confirmed the HVI findings. Open-end spinning tests saw slight improvements (reductions) in opening/ cleaning waste and ends down with thermal defoliation, depending on variety. White specks and thicks were fewer in yarn spun from thermally defoliated cotton. All other measures of yarn quality were unchanged between chemical and thermal treatments.

Boll Opener with Heat (Funk et al., 2005)

This study compared thermal, chemical, frost defoliation and thermal defoliation following an application of a boll opener. While standard chemical defoliation, thermal defoliation alone and untreated control plots all experienced open boll counts that increased from about 60% to about 83% after 19 days, an application of 1.3 pints/acre ethephon combined with thermal defoliation 6 days later resulted in open bolls increasing from 63% to 99% over 19 days--a significant increase.

Insect Mortality and Stickiness Mitigation (Bancroft et al., 2006)

Cotton from plots treated with a combination of defoliants and insecticide were compared to thermal and conventional chemical (defoliant alone) to see if stickiness could be reduced by reducing late season sucking insect populations. Because lint stickiness is highly variable, and was at low levels the two years tested, differences were difficult to quantify.

Physiology of Thermal Defoliation (Showler et al., 2006)

Comparing leaf kill and leaf drop in thermal and chemical treatments in three fields over two years showed a fairly consistent pattern: thermal defoliation resulted in near- complete desiccation within 24 hours, where chemical defoliants required 7-10 days to approach that level of leaf kill. Leaf drop in thermally defoliated plots progressed slowly, usually by the fifth or sixth day chemical defoliation leaf drop exceeded thermal levels. Leaf drop from chemical treatments could reach 80-90% in 7 to 10 days, while thermal treatment leaf drop was approximately 60-65% at the end of two weeks. Killing the leaf with heat also appears to kill the abscission layer, sticking the leaves to the stalk. There were no differences in fiber value or seed quality. Because total leaf desiccation occurred within 24 hours, thermal defoliation could make it possible to harvest in advance of adverse weather (like a hurricane).

Insect Mortality (Bundy et al., 2006 and Bundy et al., 2007)

Some late-season sucking insects (whiteflies) survived thermal treatment (about 2% in upper leaves, 11% in lower leaves) but vanished completely within one to three days in the field. The heat (integrated area on a plot of temperature over time) required to kill all stages of insects is slightly greater than that required to desiccate cotton leaves. However, because thermal defoliation completely desiccates the leaf there is no food for whiteflies (or other sucking insects like aphids) that may survive, thus they either leave or starve.

Harvest Timing (Funk et al., 2006)

Early harvest had been advocated as a method to increase harvest labor and equipment utilization or prevent significant losses from expected storms. Analysis of 138 plots from five locations over two years indicated no difference in yield, fiber value or gross return per hectare (acre) when comparing thermal defoliation with chemical defoliation. The same was true when comparing early harvest (two days after thermal treatment) with chemical defoliation harvested the usual two weeks after treatment. Though there was still a lack of statistical significance, slight yield differences were observed between early and normal harvest of thermally defoliated plots. An extra 12 days in the field added on the average 38 lbs/acre or about $24 per acre.

Remote Sensing (Fletcher et al., 2007)

Color infrared photos taken six days after treatment from fixed-wing aircraft 1500 feet above fields where thermal and chemical defoliation were being compared were scanned for digital comparison of pixel counts. This form of remote sensing resulted in desiccation and defoliation estimates that agreed with leaf counts made by trained observers on the ground. Remote sensing was validated as a potential tool for monitoring the effectiveness of thermal treatment.

Pesticide Replacement (Liu, T.X. and R.E. McGee, unpublished)
Sweetpotato whitefly (Bemisia tabaci) adults were counted, using the leaf turn method, on the third leaf from the main terminal of 10 plants in each plot while nymphs counts were made from the fifth leaf of 10 plants in each plot. Cotton aphid (Aphis gossypii) were counted from the terminals of 10 plants in each plot and boll weevil (Anthonomus grandis) were sampled by picking up all dropped squares/bolls in a 10 ft length of row within the treatment plot and counting adults, larvae and pupae. Three 'standard' chemical treatments (Dropp SC, Dropp SC +Def, and Ginstar) were compared to thermal defoliation and untreated (green) plots. Adult whitefly counts per plant were 15-42 with chemical treatment, 0-6 with thermal defoliation and 120-130 untreated. Whitefly nymphs per leaf averaged 10-15 with chemical treatment, 4-5 with thermal, and 100-110 green. Boll weevil damage in 10 ft averaged 0.3-1.3 squares with chemical and 4.7 squares with thermal. As observed elsewhere (Showler et al., 2006), boll weevils are protected from heat inside the boll, so normal eradication measures are still required.

Commercial Unit Field Trials
Eighty-two acres were treated in five days for an average of two acres per hour (including servicing). Field efficiency was approximately 67 percent as the equipment operator became familiar with turning the new machine (its turning radius was 27 feet, requiring up to three minutes for maneuvering at each end of the field). Field speed was approximately two miles per hour. Fuel consumption was 25 gallons/acre; propane cost was $52.25/acre. Since this was the first time the new commercial unit had been fielded, several component and system failures were being repaired even as the machine was in use, and many improvements suggested themselves. The data from this first field test is presented for interest only.

Conclusions

Physiological studies showed the efficacy of thermal defoliation and its impact on yield and harvest timing. Fiber quality studies indicated no damage to lint value or yarn. Entomological studies demonstrated reduced late season pest populations.

The advantages of using heat to prepare cotton for harvest include:

- No fiber damage- bale value and yarn quality are the same with thermal defoliation as they are with conventional chemical defoliation.
- Equivalent material costs- Propane and defoliant chemicals have long cost approximately the same per acre as both rise and fall with crude oil prices.
- Heat treated cotton is ready to pick in two days or less- Producers can improve harvest equipment utilization as well as bring in their crop in advance of a storm.
- Weather independent- Treatment is possible on a windy day, before a rain, or when nights are cold. And treatment is independent of flight restrictions.
- Once is enough- Even Pima cotton is ready for harvest after just one treatment.
- Thermal defoliation is environmentally sound- There is no chemical drift to contaminate dwelling places, waterways, wildlife habitat, or nearby crops.
- There is no chemical residue- Thermal defoliation is approved for organic production, and thermal defoliation makes it possible to sell gin trash as feed.
- Kills bugs dead- 24 hours after thermal defoliation late season sucking insects are completely gone, killed outright or starved off, for "NO STICKY COTTON!!!"

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Disclaimer

Names are necessary to report factually on available data; however the USDA neither guarantees nor warrants the standard of any product and the use of a product name by the USDA implies no approval of the product to the exclusion of others that may be suitable.

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